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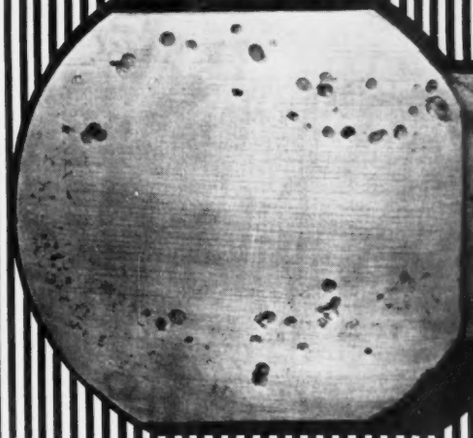
THE FOUNDRY



Compare these Castings

Section of round bar poured from plain cast iron. Note the dirt and blow-holes.

Section of round bar of same metal purified with 3-10 of 1% of Titanium Alloy.

TITANIUM

The Wonder-Working Alloy

The two illustrations above were made from unretouched photographs of actual castings. They are worth studying. They point to an easy, certain, and inexpensive way to make castings of better quality than you ever thought possible. Titanium Alloy is a combination of the metal Titanium with best quality iron electrically refined. It is convenient to use. Simply adding it to the charge in cupola or furnaces produces sound, healthy castings free from dirt, blow-holes and shrinkage cracks. The character of the metal itself is changed. It is closer grained and under test shows a most remarkable increase in resistance to wear and in tensile and compressive strength.

Titanium Alloy is the cheapest high grade alloy on the market. Cost of adding it to cast iron ranges from 25c up per ton of finished product.

In steel, Titanium Alloy produces effects even more remarkable than in cast iron.

Our Booklets are of Vital Interest to Every Maker and User of Iron and Steel

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You are paying for it every day with the money it would save you.

You may not believe this statement, but a careful investigation would convince you of its truth.

You are paying for the Auto Sand Mixer because it will cut your molding sand cheaper than your molders or laborers can cut it. You are paying for it because it will cut your sand better and reduce your lost castings and increase your output.

You are paying double price for it if your molders are cutting their own sand, because they are losing production by wasting skill, time and energy on non-productive work which the Auto Sand Mixer would do better and cheaper.

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The business ability and judgment which gave these firms their recognized standing in the trade is the same business ability and judgment which caused them to adopt the Auto Sand Mixer.

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We install the Auto Sand Mixer on trial and take all the risk ourselves. Please write us today.

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IF YOU USE OUR

YOU WILL GET RESULTS

ANALYSIS

Silica -	97.72%
Iron -	.72%
Aluminum	.34%
Zinc -	.12%
Manganese	.34%
Combined water and Organic matter	.76%

¶ YOUR CASTINGS will be free from sand blisters and will not burn out.

¶ Chipping will no longer be necessary, and Castings will be clear blue.

¶ Cleaning will be practically eliminated for our sand peels off in cakes.

Franklin Silica Sand Co.
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and forget your casting troubles.

LION LEAD is simply the purest, brightest and most refractory Ceylon Plumbago Dust produced on the island. Any Plumbago man knows this and will freely admit it.

It is shipped direct from our own large curing establishment at Colombo, Ceylon, to our Bethlehem Plant, finely and uniformly powdered and sent out to the trade.

WE GUARANTEE

perfect uniformity and every pound to show over 80 per cent graphitic carbon.

You may think the price high but you will get more than your money's worth.

Save your temper---your pocket book and your castings by using

LION LEAD

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Complete Equipment for Foundries

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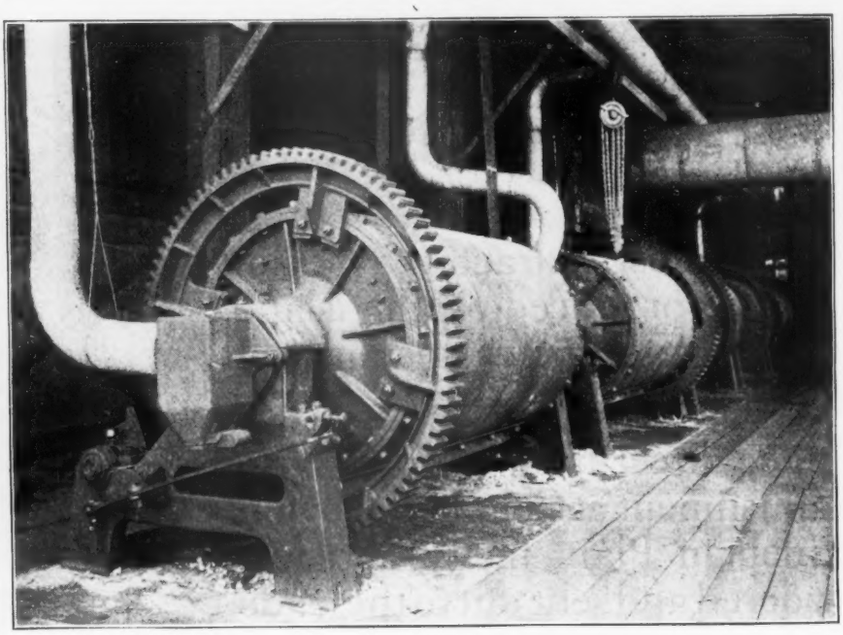

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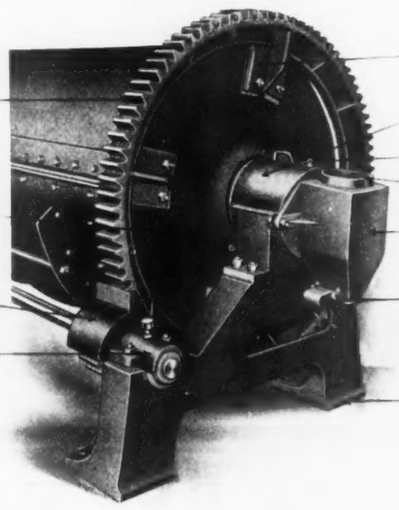
Five Type A Exhaust Tumblers—Bessemer Soil Pipe Co., Bessemer, Ala.



Gear bolted to head. Cast steel gears for 48" barrel and larger.

Trunnion journal box bolted to standard, bearing chilled cast iron, ring oiler.

Gear guard combined with cap.

Box bored to jig removable babbitted shell, bearing dust proof.

Lugs turned, gear bored, faces machined.

Dust proof cap.

Oil hole plug.

Exhaust pipe connection.

Dust box.

Automatic lid.

Base plates planed underneath.

These Tumblers Designed and Constructed to withstand for years the severest service---
Quotations and Specifications on Request.

CUPOLAS	TRUCKS	CORE OVENS	O. H. STEEL FURNACES
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ELEVATORS	AIR HOISTS	CONVERTERS	ANNEALING OVENS

WHITING FOUNDRY EQUIPMENT CO.

MANUFACTURING ENGINEERS AND DESIGNERS

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See other Adv. on Page 103

THE FOUNDRY

Vol. 37, No. 5 Cleveland, Ohio, January, 1911 Whole No. 221

CONTINUOUS CAST IRON PIPE FOUNDRY

Straight floor system for the continuous production of water pipe---Cycle of operations and method of making cores

AS THE manufacture of cast iron pipe is almost entirely repetition work involving large tonnages, pipe foundrymen are installing continuous systems of various types, not only to effect economies in operation and to improve the quality of the product, but also for the purpose of minimizing the arduous hand labor of this line of work, which makes it difficult to retain a full quota of men in these plants, particularly during the summer months. One continuous molding and casting plant, installed by the United States Cast Iron Pipe & Foundry Co., in its Scottdale, Pa., works, described in THE FOUNDRY, December, 1907, is designed on the circular floor plan, the flasks rotating on a turntable for the successive steps of molding, coring, pouring, shaking out, etc. Electric rammers are used for making the molds and hand labor is largely eliminated. The objection raised against this, as well as against other circular, continuous systems, is that a delay, or accident at any point, either delays or stops the entire cycle of operations.

When James B. Clow & Sons, Chicago, decided to erect a pipe foundry at Coshocton, O., an investigation was made of all the American and European continuous systems of cast iron pipe manufacture. The works of Cochrane & Co., Ltd., Middlesbrough, Eng., were one of the numerous plants visited by C. M. Aland, superintendent of the Coshocton foundry, who conducted the investigation for the Clow company. In this plant large sizes of water pipe are successfully made by a straight

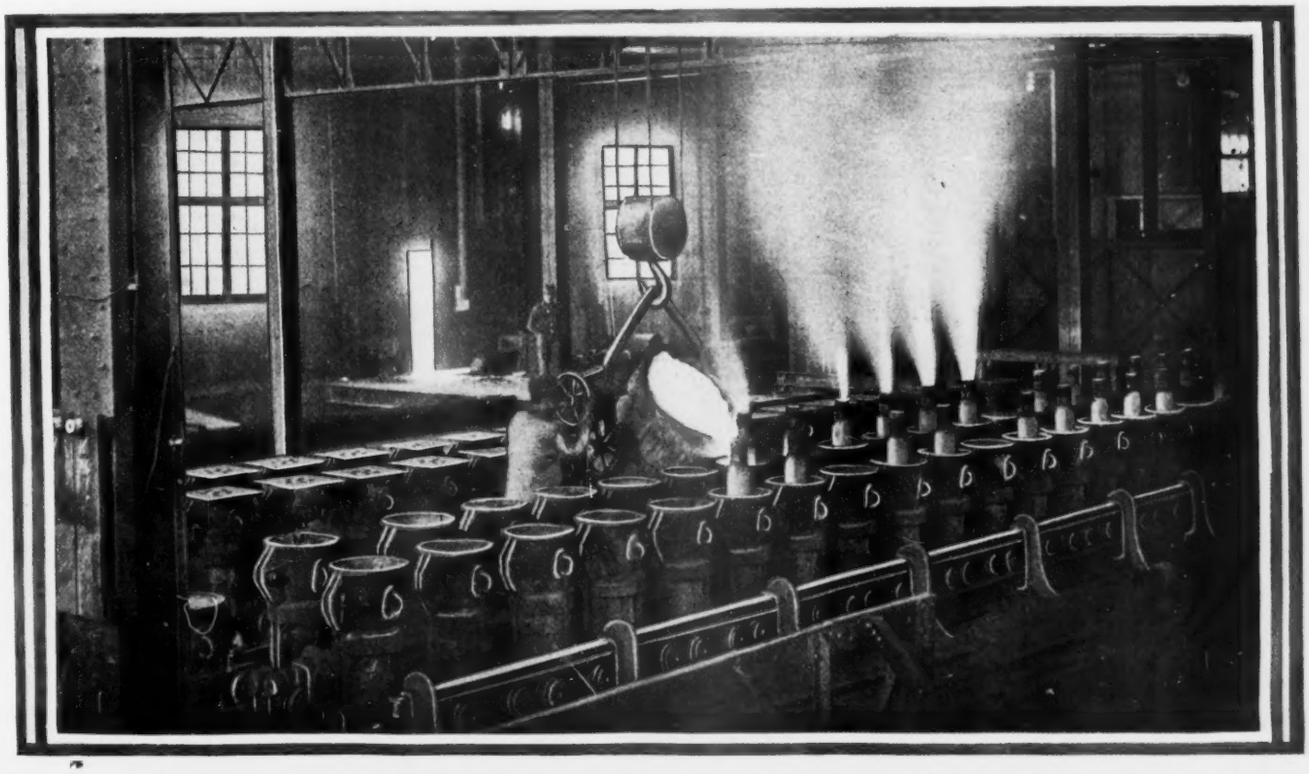


FIG. 1—CONTINUOUS CAST IRON WATER PIPE MANUFACTURING PLANT, SHOWING THE METHOD OF POURING THE MOLDS

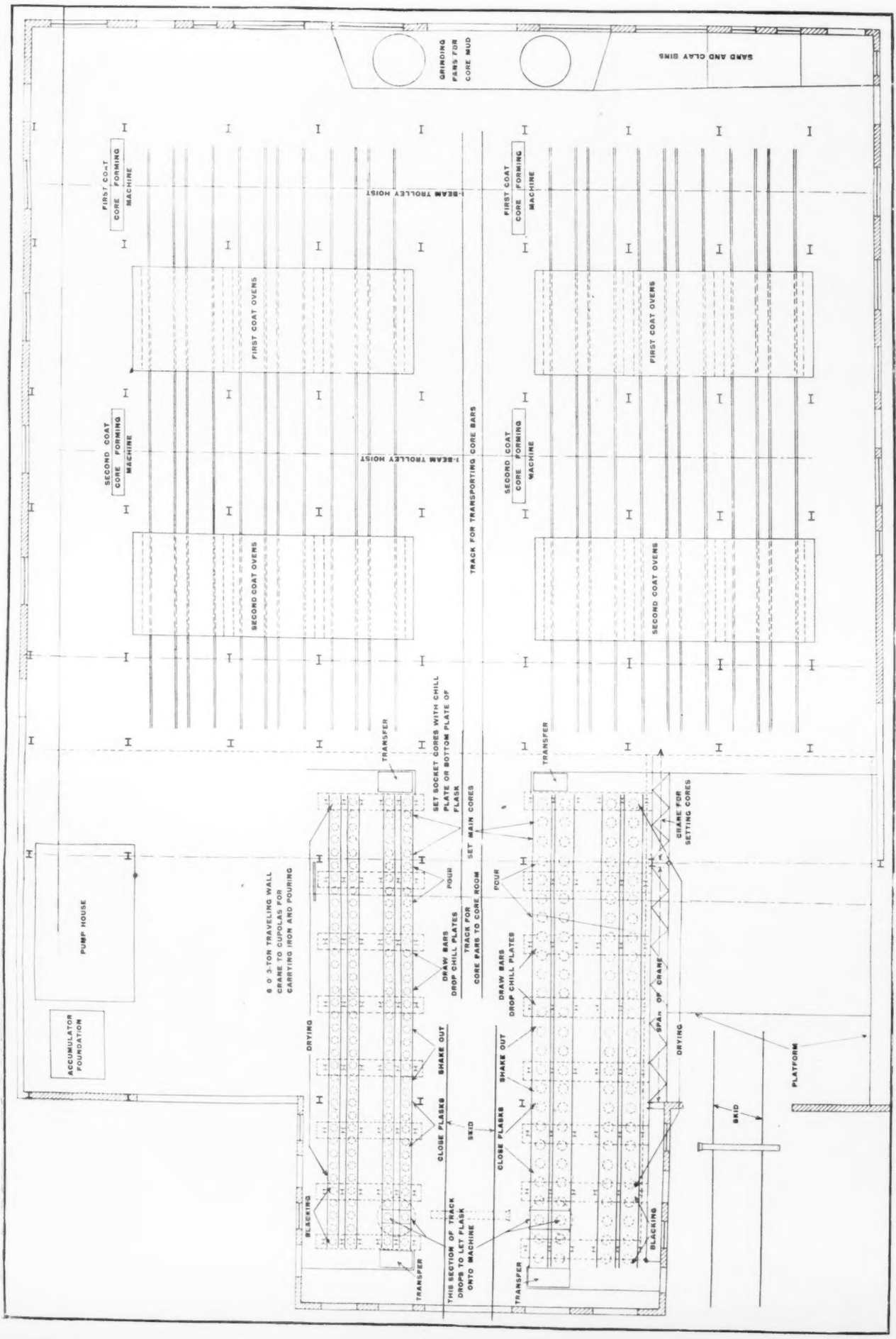


FIG. 2—GROUND PLAN OF THE CONTINUOUS CAST IRON PIPE SHOP OPERATED BY JAMES B. CLOW & SONS, COSHOCTON, O., SHOWING THE ARRANGEMENT OF THE MOLDING AND CASTING PITS, CORE OVENS, CORE FORMING MACHINES, ETC.

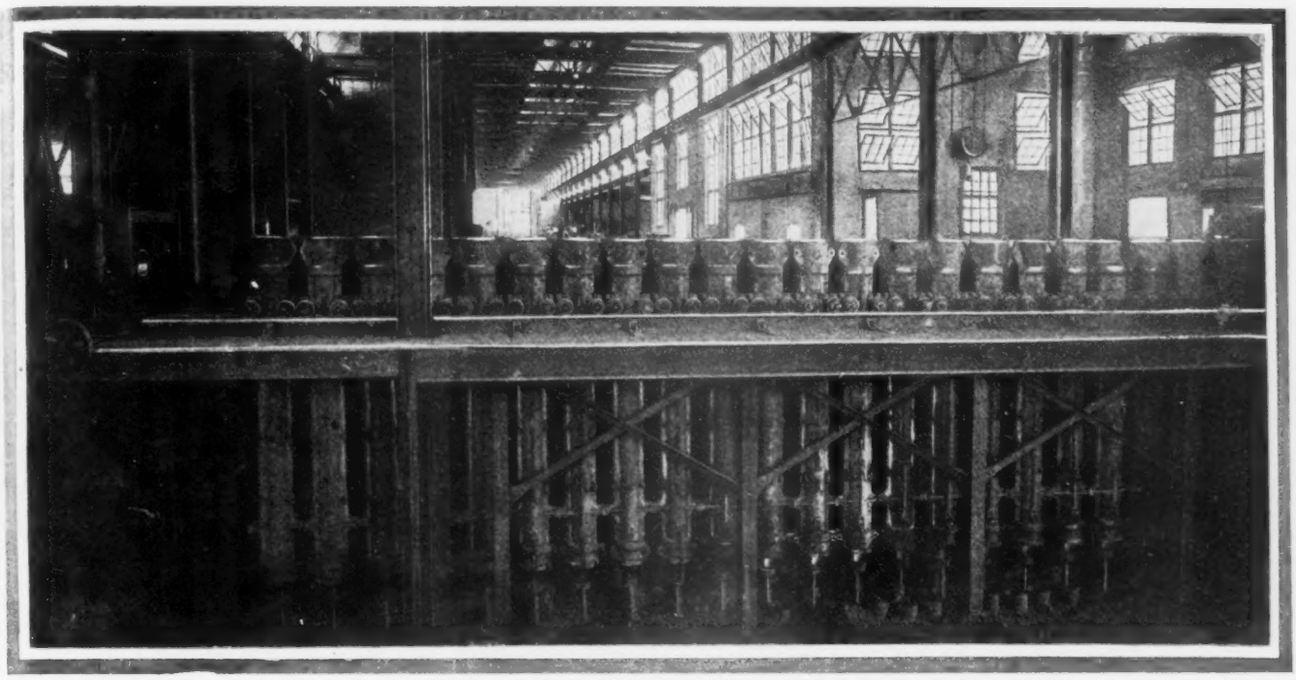


FIG. 3—VIEW OF THE MOLD DRYING TRACK AND THE ARRANGEMENT OF THE CONTINUOUS PIPE MANUFACTURING PLANT, LOOKING TOWARD THE GRAY IRON FOUNDRY

line, continuous process, devised by Fred Herbert, of Birtley, Eng., and as it embodies none of the objectionable features of some of the circular systems investigated, it was concluded to operate the Cochocton foundry by this method. As each flask is self-contained and is not attached to any part of the plant or structure, there are no vexatious delays due to accidents, or other causes, which so frequently delay the operation of circular, continuous systems. If it is found necessary to remove one of the flasks forming a part of the Herbert system, the unit can be lifted out by a crane without impeding the forward movement of the other flasks, or retarding operations.

A diagrammatic illustration of the successive operations of pipe manufacture by the Herbert process is shown in Fig. 9. The flasks, which are vertically suspended from four parallel tracks, are mounted on four wheels fixed on axles, forming a truck on which each flask is carried. The flasks are longitudinally divided into two sections, and each half is carried on a small wheel operating on the upper side of each axle, so as to permit of opening the flask when shaking-out the casting. The rails are on a level with the foundry floor and the flasks are suspended in a pit the entire length of the con-

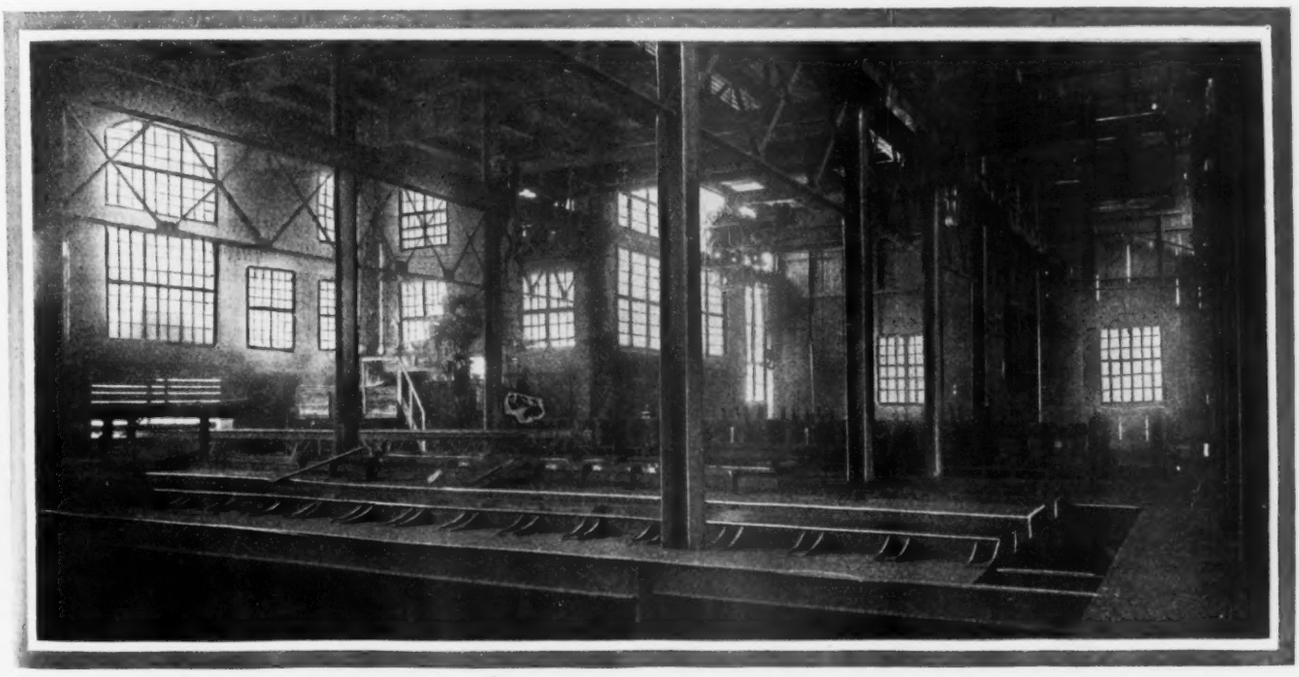


FIG. 4—GENERAL VIEW OF THE PIPE MOLDING AND CASTING PITS, SHOWING THE SAND PLATFORM OVER THE MOLDING MACHINE IN THE BACKGROUND

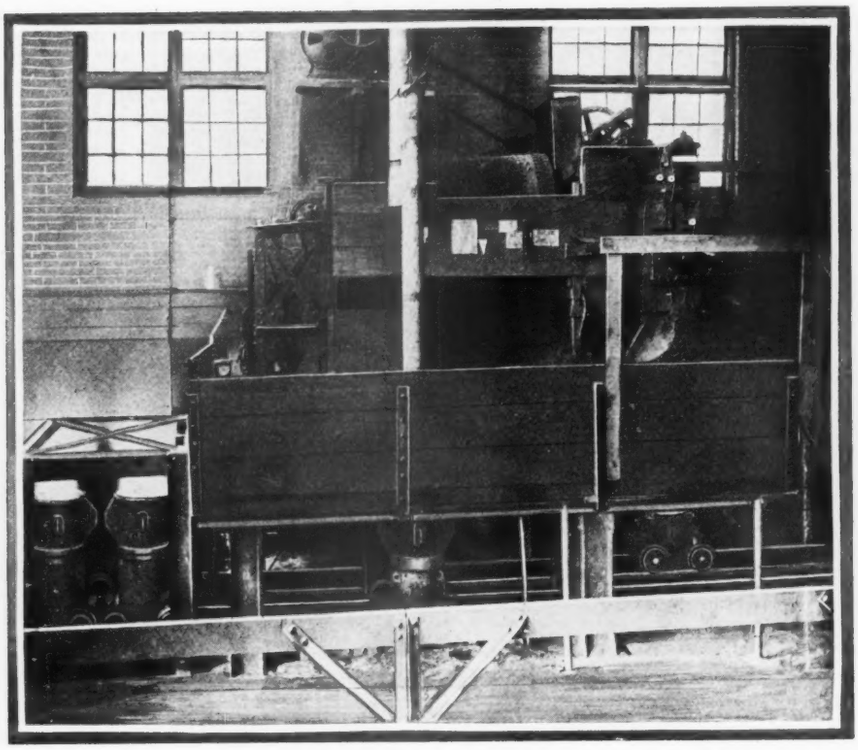


FIG. 5—SAND PLATFORM OVER THE MOLDING MACHINE, SHOWING TWO MEASURING TUBES, WITH THE TRANSFER CAR AT THE LEFT

tinuous plant, in which are also located the hydraulic molding machine, gas burners for drying the molds and the sand tempering and preparing plant. The hydraulic molding machine is shown in this illustration, and after the flasks are shaken out and closed, they are moved forward on the track to this point, lowered onto the base of the machine, sand is filled-in around the measuring tube and the mold is rammed by the upward movement of the hydraulic piston of the molding machine. The mold is then moved forward onto a transfer car operating on a track at right angles to the main runway, and extending the width of the continuous plant. The flask is then transferred to the mold drying track, and after the blacking is applied, is permitted to pass slowly over the gas burners in the pit to dry the mold. At the end of this track, and after having passed over the gas burners, the flask is again moved onto a transfer car and is delivered to the first track, from which it was suspended while the mold was rammed. After attaching the bottom plate, the core is set by a traveling crane, and the flask is again moved forward into position for receiving the metal. After casting, the core bar is pulled out, and after opening the flask the casting is withdrawn by a crane, the shaking-out operation taking place directly over the sand-preparing and tempering plant in the pit. The flask is then closed and is again moved forward to the molding machine, and the same cycle of operations is repeated without cooling the flask.

FIG. 6—A CLOSER VIEW OF THE DRYING TRACK, SHOWING THE GAS BURNERS UNDERNEATH THE MOLDS

The general arrangement of the continuous pipe foundry built by James B. Clow & Sons, at Coshocton, is illustrated in Fig. 2. It will be noted that the core department is an essential feature of this plant and it is so arranged, with relation to pipe casting department, to effect a minimum of expense in the handling and setting of the cores. The building is 169 x 136 feet, with an offset at the molding machine end, 33 x 60 feet, and is 30 feet 4 inches high in the clear. Monitor ventilators, extending the full length of the building, are provided to carry off the smoke and gases when pouring the molds. Two continuous units have been installed for producing 3, 4 and 6-inch, and 8, 10 and 12-inch water pipe, respectively. The plant for casting pipe of larger sizes has not yet been placed in operation, although it is practically a duplicate of the unit for manufacturing the smaller pipe, which will be described. Extending the width of the plant and underneath the offset, is a 12-foot basement in which are located the molding machines, sand tempering and preparing plant, burners for drying the molds, department for making and drying the socket cores, hydraulic ram for attaching the bottom plates, pump house, accumulator and other hydraulic equipment.

The flasks are vertically suspended from four tracks supported by heavy structural steel members, as shown

in Figs. 3 and 6. On two tracks the molds are blacked and dried, while on the other two bottom plates are attached, cores are set, molds cast, core bars pulled, castings shaken-out and the molds rammed, which is the first of the cycle of continuous operations. The tracks are 20½-inch gage and extend a length of 72 feet. The flasks, as previously noted, are divided longitudinally into two sections and are supported on the tracks by four wheels. After shaking-out, the flasks are closed, the two halves merely being pushed together, and are held by eight cotter pins. The molds are rammed and poured, bell-end down, and the flasks travel in pairs for the various operations, such as molding, pulling the core bars and shaking-out the castings.

After the pair of flasks have been closed they are moved over a section of track directly above the hydraulic molding machine, which carries two pipe patterns on pistons in independent cylinders. The tracks are lowered by a hydraulic ram, permitting the flasks to be centered over the molding machines in the pit, as shown in the background, Fig. 15. Each flask is attached to the base of the molding machine by four cotter pins. After the flask has been centered and while it is being attached to the base of the machine, a measuring tube is lowered through the center of the flask. This tube, for 6-inch pipe, is 6½ inches in diameter and carries on its lower end a chilled cast iron cone which centers over the pattern shown partly raised, in Fig. 15. This cone is 7 3/16 inches in diameter, approximately 1/16 inch larger than the pattern, which is 7⅛ inches in diameter for 6-inch pipe. From the sand platform, located above the molding machine, Fig. 5, the sand is shoveled into the flask around the measuring tube, partly elevated out of the flask in this view, while in the background is a tube raised to its highest position showing the cone attached to the end. The mold is then ready for ramming, which is accomplished by the hydraulic piston carrying the pattern, forcing the chilled cast iron cone on the lower end of the measuring tube through the sand. Near the end of its stroke, the main pattern engages the socket pattern, lifting it, thereby molding the socket. The socket pattern is held in position by hydraulic rams, and at *A*, Fig. 12, it is shown in its normal position before it is engaged by the main pattern, while at *B* it has been lifted and is in the position it assumes when molding the socket, or bell end of the pipe. The spigot pattern, *C*, Fig. 24, is set on the end of the main pipe pattern, as shown at the right, Fig. 12. In addition to the spigot, this pattern forms the four gates and the pouring basin. The main pattern is then lowered and the spigot pattern drops by gravity into the upper end of the flask, forming the basin, gates and guides for the core in one operation. The main pattern is again raised, carrying the spigot pattern about 2 inches above the mold, as shown at *D*, Fig. 12, and at *C*, the spigot pattern is shown suspended before it is set on top of

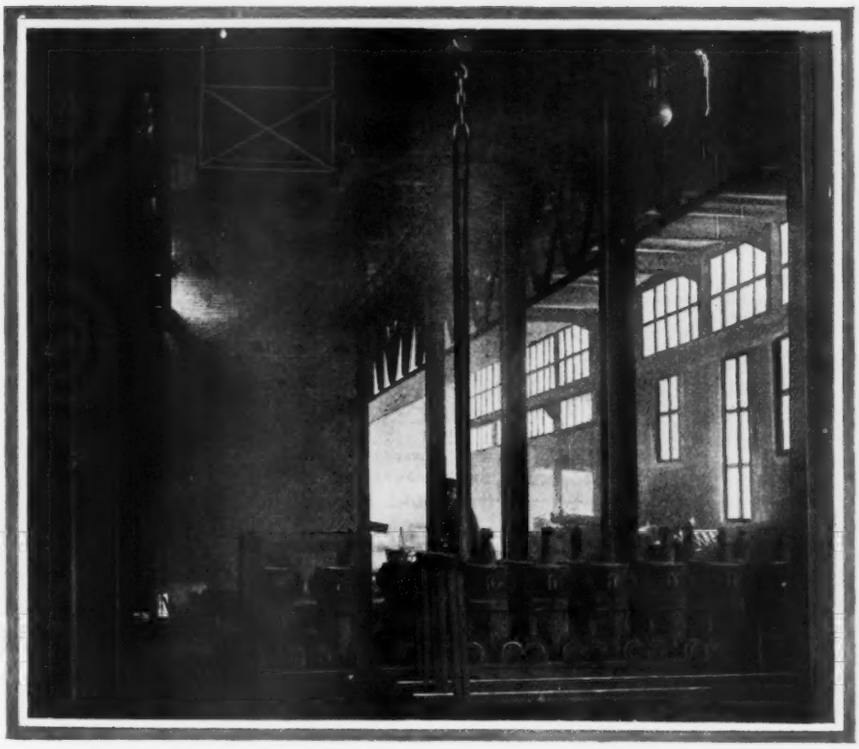


FIG. 7—SETTING THE MAIN PIPE CORES BY AN ELECTRIC TRAVELING CRANE. ONE OF THE TWO TRANSFER CARS IS ALSO SHOWN

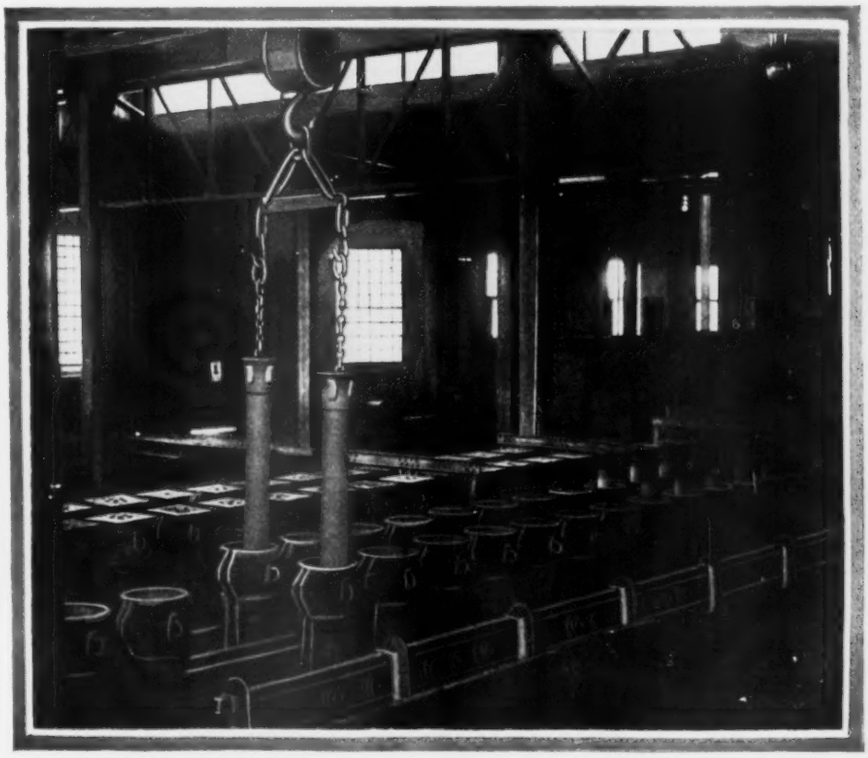


FIG. 8—SHAKING-OUT THE PIPE BY AN ELECTRIC TRAVELING CRANE

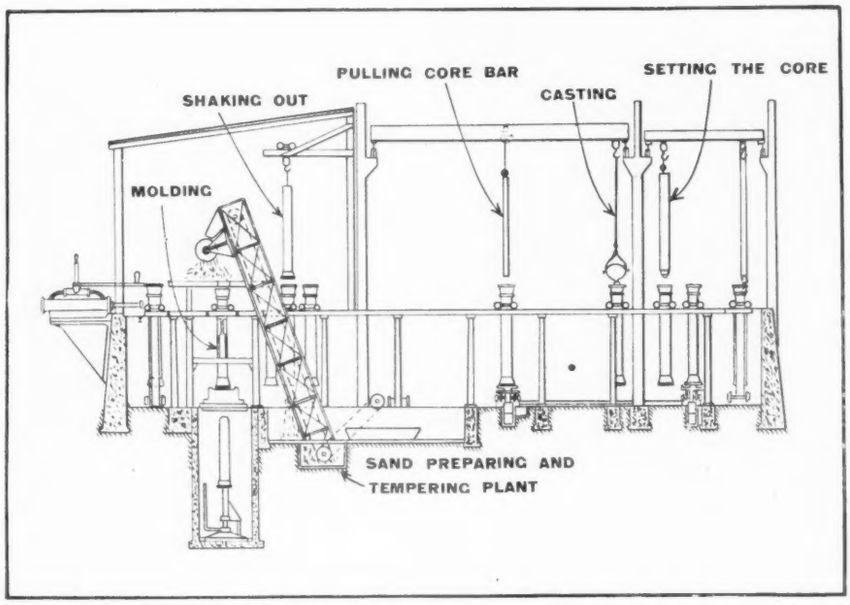


FIG. 9—DIAGRAMMATIC VIEW OF A PIPE MOLDING AND CASTING PLANT, SHOWING THE CYCLE OF ALL OF THE OPERATIONS

the main pattern for lowering into the mold. The main pattern is then withdrawn and the socket pattern is lowered by the hydraulic rams which have held it in position, thus completing the mold. The approximate time required for making a complete mold is approximately 2½ minutes.

The cone of the measuring tube, which is forced through the sand ahead of the main pattern, thus ramming the mold, is 1/16 inch larger than the pattern. It has been found that there is a sufficient elasticity in the sand to compensate for this difference in diameter and the molds are all true to the size of the pattern. In lowering the pattern through the mold it has a sleeking effect on the sand, which is subsequently reflected by the smooth surface of the castings. For making pipe of smaller diameter, no additional flask equipment is required and the only changes necessary are measuring tubes and patterns of a smaller diameter. This permits of molding 3, 4 and 6-inch pipe in the same flasks and greatly reduces the expense of this equipment. The density of the mold can also be regulated as desired, by either increasing or decreasing the diameter of the measuring tube. If it is deemed advisable to ram the molds harder than usual, the diameter of the measuring tube is slightly decreased, thus permitting the use of a greater quantity of sand. On the other hand, the molds can be rammed soft by increasing the diameter of the tube, thereby reducing the amount of sand filled into the flask. This method of ramming can be almost considered the ideal for which foundrymen have been striving, as the mold is rammed uniformly hard next to the pattern, decreasing in density to the side of the flask, thus venting freely.

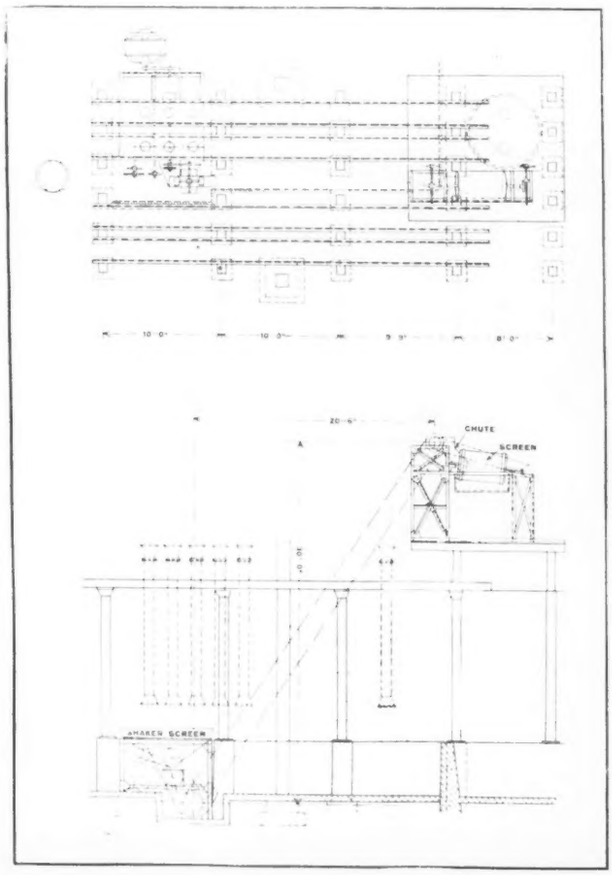


FIG. 10—GROUND PLAN AND SIDE ELEVATION OF THE SAND-PREPARING, TEMPERING AND HANDLING PLANT

A sectional view of the pipe molding machine is shown in Fig. 12. It consists of two hydraulic cylinders having pistons 10 feet long, operated independently of each other. Each piston carries a pipe pattern which is fixed vertically into the piston, the pattern being the full length and diameter of the pipe to be molded. The socket or bell pattern is located at the lower end of the pipe pattern and is made to move up and down in a casing accurately machined concentric with the pipe pattern. The cylinders are 10 inches in diameter and are encased in a pit, 24 feet 9 inches deep and 7 feet 5 inches outside diameter. A side elevation of the arrangement of the molding machine and runway is shown in Fig. 23.

After the removal of the cotter pins by which the flask was attached to the base of the molding machine, the track with the suspended mold is again raised to the level of the runway and is moved along onto the track of the transfer car shown at the left in Fig. 5, which has a capacity of four molds. This car, with its finished molds, is then transferred by a hydraulic pusher to the runway carrying the two mold drying tracks. Another hydraulic ram pushes the molds from the transfer car, and these molds in turn move all of the flasks on the two drying tracks. In this way the molds are steadily carried forward,

not only on these tracks, but on the other runway, where the coring, casting and shaking-out are done. After blacking, the molds pass over a series of open gas burners, arranged in two rows, one under each track. The outside row of burners is clearly shown in Figs. 3 and 6, which also illustrates the vertical suspension of the flasks from the drying track into the pit. With the burners underneath the molds, every opportunity is afforded for close inspection and examination, and imperfect molds are marked to prevent the setting of cores and castings, thereby effecting a considerable reduction in the losses from defective castings. The two rows of burners extend the entire length of the runway and a mold remains about one hour and 40 minutes on the drying track. This period has been found ample to sufficiently dry the molds for casting.

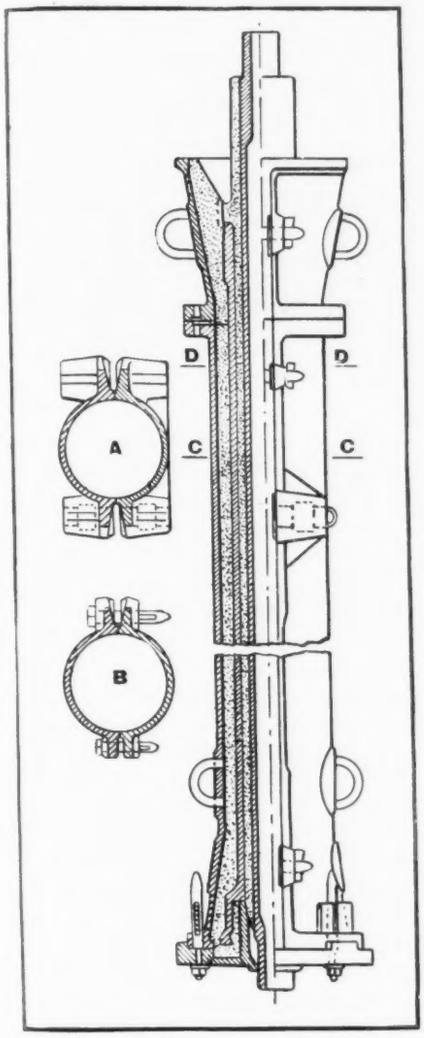


FIG. 11—SIDE ELEVATION AND LONGITUDINAL SECTION OF A PIPE FLASK CONTAINING A CASTING

At the opposite end of the runway, Fig. 7, the molds are again moved onto a transfer car and are conveyed to the other two tracks for coring, casting, shaking-out, etc. The bottom plates are attached in the pit, being raised into position underneath the molds by hydraulic hoists. A bottom plate with a sand head in position, which forms the socket of the pipe, as well as the centering socket for the main or body core, are shown at *A*, Fig. 24. A part section of a mold, after casting, is illustrated at *A*, Fig. 13, *D* being the core, *E* the casting, *G* the socket core and *F* the metal cone socket, into which is received the cone-shaped end of the body core, thereby forming a centering support for the core at the bottom of the mold. A part side elevation and longitudinal section of a flask showing the relation of the mold, core and head in assembled position, with the pipe section cast therein, is shown in Fig. 11; *A* and *B* are detail views in transverse section on the lines *CC* and *DD*, Fig. 11, respectively; *B*, Fig. 13, is a transverse section of the bell end of the mold showing the bottom plate, socket core and cone for centering the core.

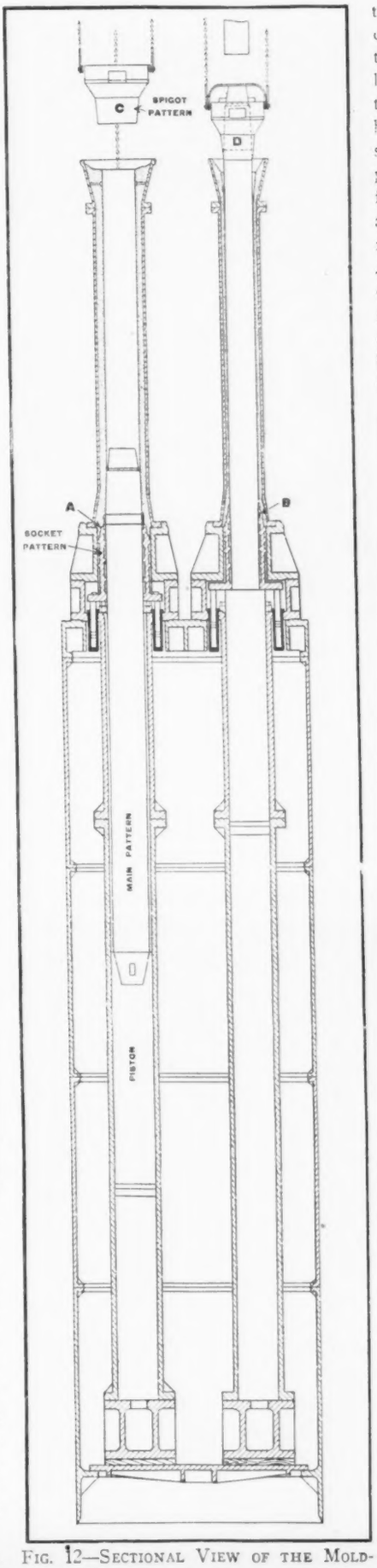


FIG. 12—SECTIONAL VIEW OF THE MOLDING MACHINE, SHOWING THE HYDRAULIC CYLINDERS AND PATTERNS

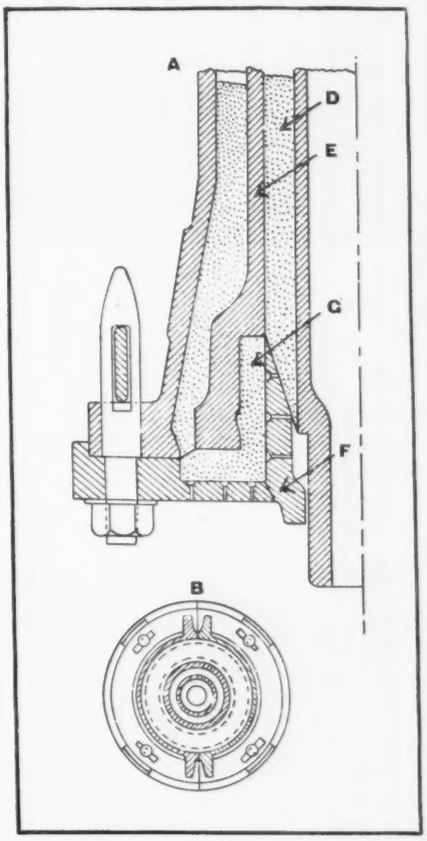


FIG. 13—PART SECTION OF THE BOTTOM OF THE FLASK, SHOWING THE BOTTOM PLATE, SOCKET CORE, ETC.

After attaching the bottom plates, the molds are pushed off the transfer out onto the castings tracks by hydraulic rams and the main body cores are lowered into position by an elec-

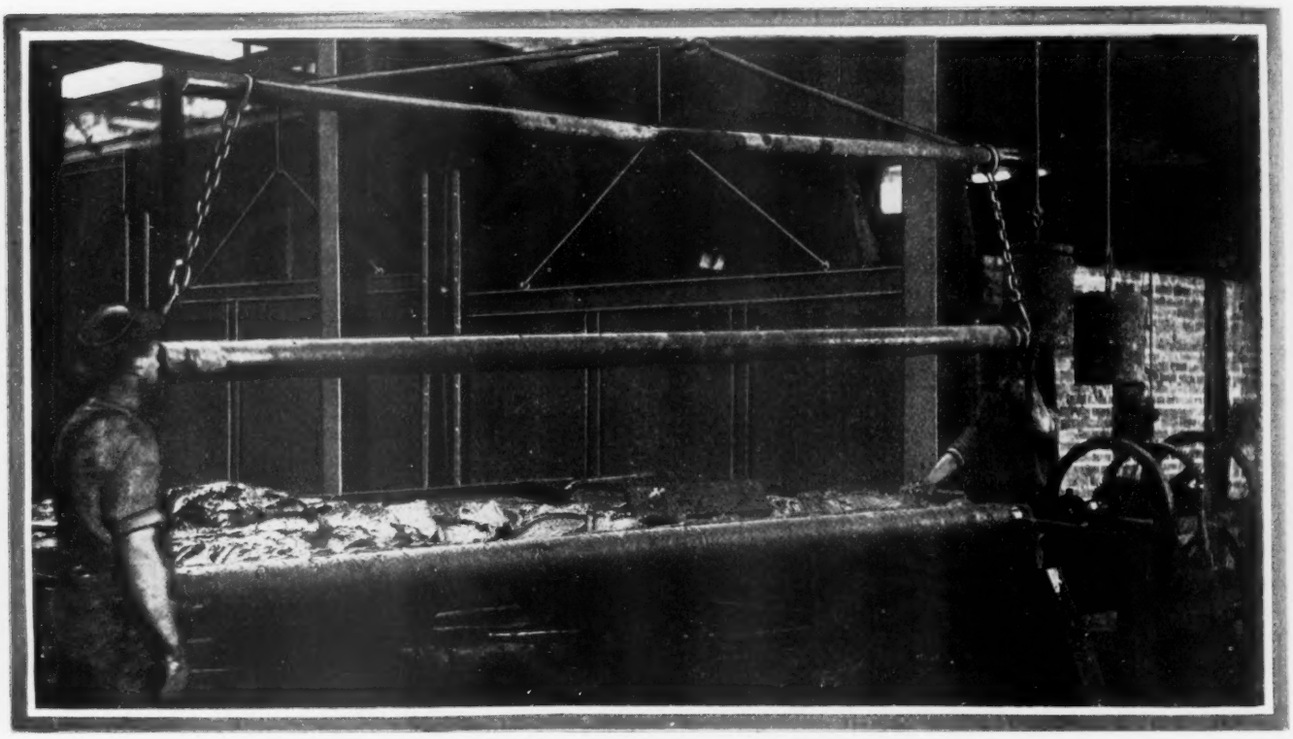


FIG. 14—CORE-FORMING MACHINE FOR APPLYING THE FIRST COAT OF MUD

tric traveling crane, as illustrated in Fig. 7. This core is self-centering, being cone-shaped at its lower end and is received into a cone-shaped socket on the bottom plate, while a collar, turned onto the core about 6 inches from its upper end, not only centers the core at the spigot end of the mold, but also completes the gates and the pouring basin. As additional molds are transferred to the casting tracks, those already cored are gradually moved forward to the point where they are poured.

At present the metal is cast from a geared ladle, suspended from an electric traveling crane, Fig. 1, but a 3-ton wall crane is being installed for this purpose, which will also carry the metal from the cupolas to the pipe casting pits. After casting, the flasks are again moved forward on the tracks and the core bars are pulled from two flasks at a time, by an electric traveling crane, which deposits them on a car on which they are returned to the core department. The cotter pins holding the halves of the flask together are then knocked out and the flasks are opened to permit of the removal of the castings. Two chains, hooked onto a bail suspended from the crane, are lowered through the castings, automatically gripping the pipe at the bottom. The castings are shaken out, as illustrated in Fig. 8, are lowered onto a skid, 16 feet 4½ inches wide, at the side of the runway, and are rolled out of the building into the cleaning shed. The flasks are again closed and, without permitting them to cool, are slowly moved forward onto the machine section of the runway for another cycle of operations. In Fig. 2, the sequence of the various operations is clearly indicated. The pit for 3 to 6-inch pipe is equipped with 120 single flasks, equal to 60 double flasks in the parlance of the pipe founder, and to complete the cycle, approximately two hours are required. This pit has a capacity of 600 pipe in 20 hours, and it is the intention to operate 20 hours per day, divided into two

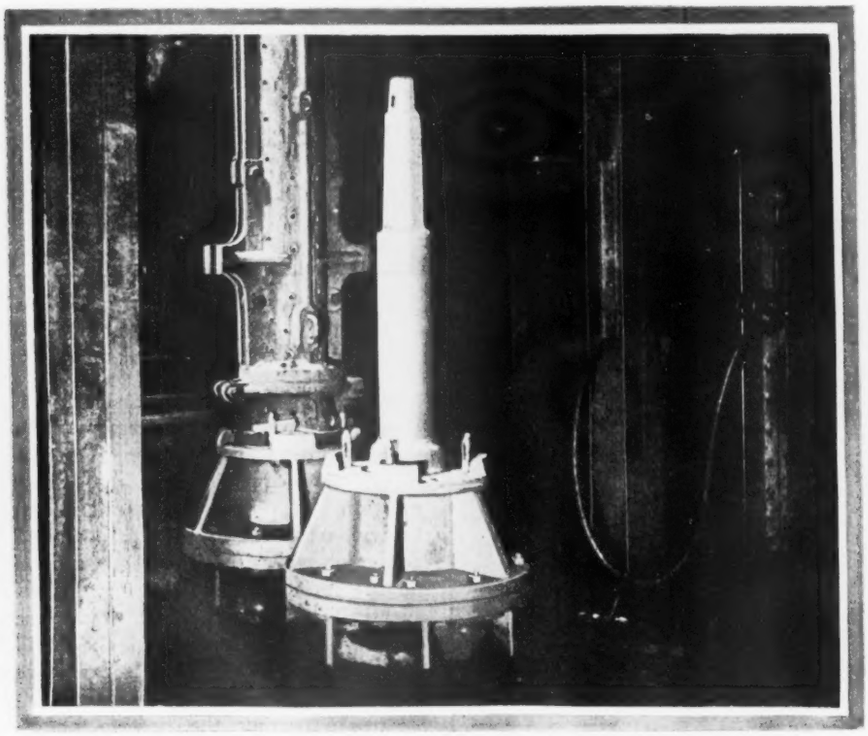


FIG. 15—THE MOLDING MACHINE, SHOWING A FLASK ATTACHED IN THE BACKGROUND, AND THE MACHINE WITH THE PATTERN PARTLY RAISED BEFORE THE FLASK IS LOWERED, IN THE FOREGROUND

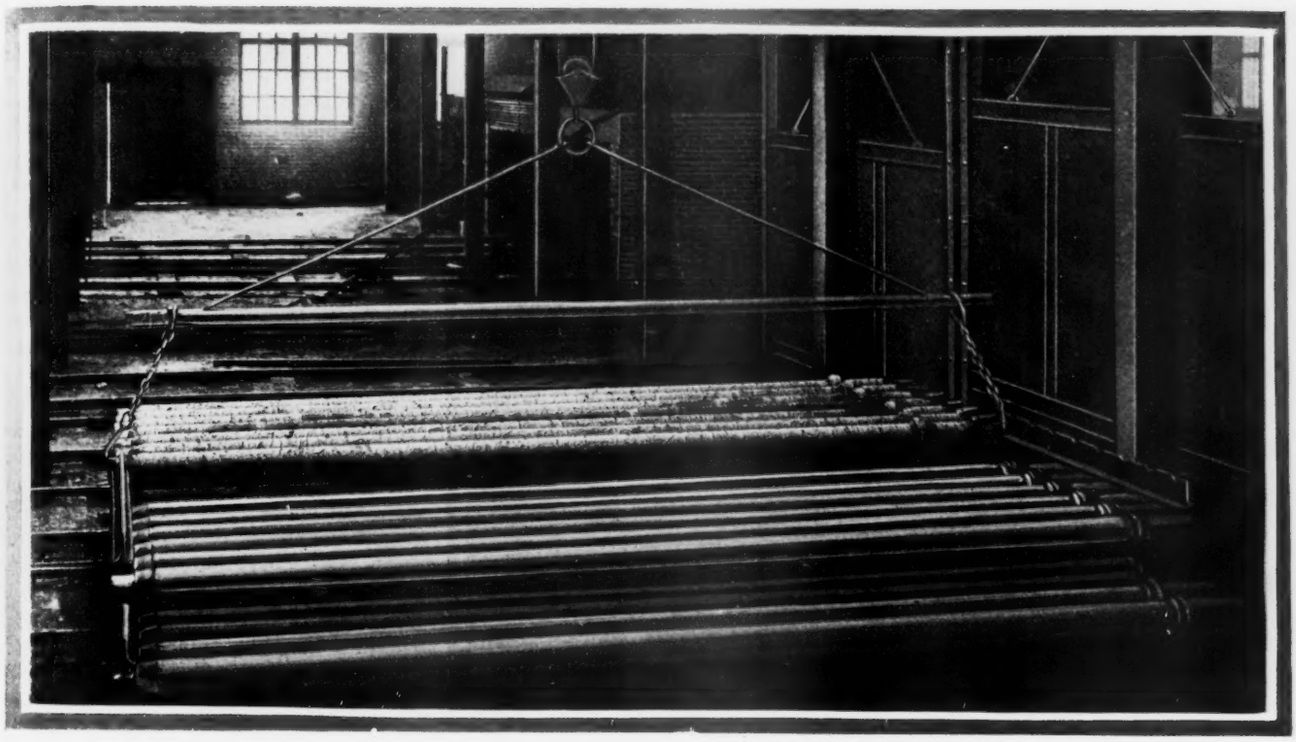


FIG. 16—CORES AFTER RECEIVING THE SECOND COAT ARE SHOWN IN THE FOREGROUND, AND THE CORES ON THE BUGGY IN THE BACKGROUND HAVE JUST BEEN RECEIVED FROM THE FIRST COAT CORE OVEN

shifts. As the runway of the pit for large pipe is of the same length as the one for small pipe, it will not accommodate as many flasks, but there will be a sufficient number to allow ample time for drying the molds.

To insure clean castings the pipe sections are cast with a 3-inch head, which is cut off, after cleaning, leaving a sharp, clean head on the spigot end and insuring a better fit in the bell end than can otherwise be obtained, thereby greatly reducing the amount of lead in making the joints and effecting a saving of upwards of $1 per ton in the cost of laying the pipe. In the cleaning shed the socket irons are knocked out and the core sand in the pipe is removed with scrapers. After cleaning, the pipe is skidded to the head cutting-off machines, one of these being shown in Fig. 17. From the machine the pipe is elevated by a cradle to the skid leading to the heating oven, and after attaining the proper temperature, is conveyed on skids to the tar tanks. The pipe is immersed in the tar on a cage operated by compressed air, and when lifted out of the tar, the cage tilts the pipe, draining off the surplus tar. After dipping, the pipe is subjected to a test of 300 pounds hydrostatic pressure, weighed, marked and transferred to the storage yard for shipment. Pipe for immediate shipment is conveyed from the test house and loaded into cars by a 5-ton trolley which commands the loading track. The storage yard is also served by a 5-ton bridge crane, 110-foot span and 400 feet long, installed by the Cleveland Crane & Car Co., Cleveland.

The sand tempering and preparing plant, plan and side elevation of which are shown in Fig. 10, is located directly below the shaking-out section of the runway. Here the hot sand is tempered, mixed with new sand, riddled and delivered in buckets on a conveyor to a chute above the sand platform, Fig. 5, from which it falls into a rotary screen and is dropped onto the sand platform. No difficulties have been experienced from the use of this warm sand, in fact, it is

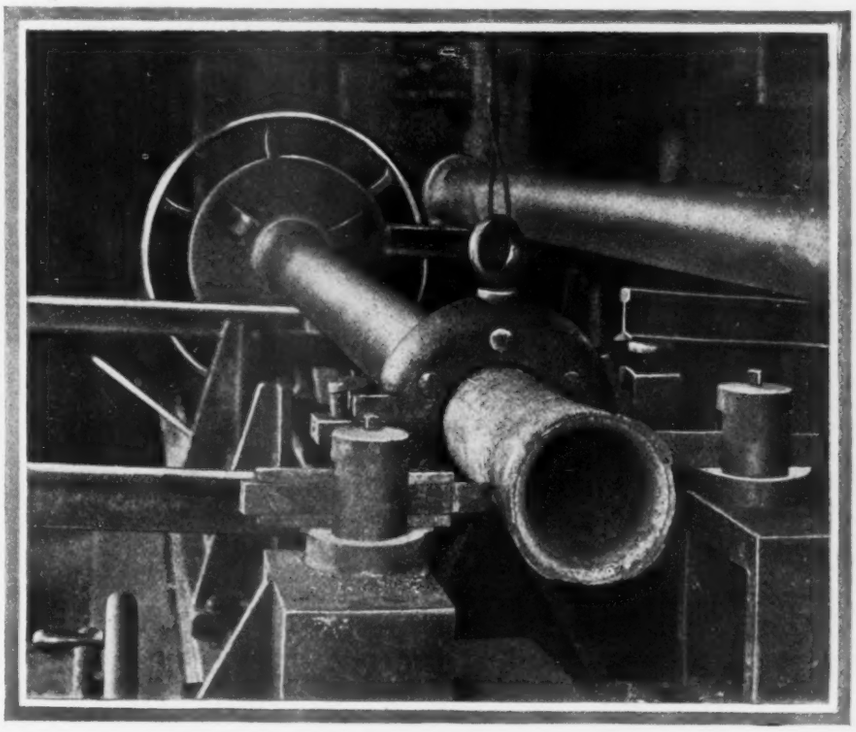


FIG. 17—ONE OF THE MACHINES FOR CUTTING-OFF THE HEADS FROM THE SPIGOT ENDS OF PIPE

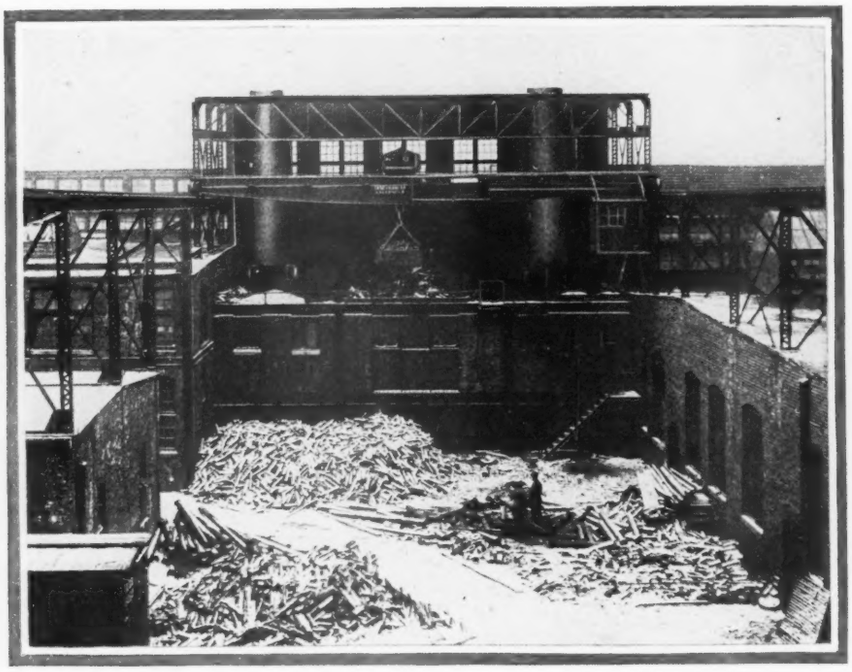


FIG. 18—VIEW OF THE STORAGE YARD, LOOKING TOWARD THE CHARGING FLOOR

considered an advantage, as it facilitates the drying of the mold. The flask, also being hot when the mold is rammed, to some extent also aids this operation. The sand-preparing and handling plant was installed by the Standard Sand & Machine Co., Cleveland, and is operated by a motor located in the pit. Socket cores are also made in the pit at a point close to the hoists which elevate the bottom plates to the lower end of the flasks. The ovens for drying these cores are likewise in the pit and are fired by producer gas.

The department in which the body cores for the pipe are made is one of the essential features of the plant, and it is so arranged that the various operations follow each other in natural sequence, steadily carrying the cores forward until they are delivered to the pipe shop. A plan view of the core department, showing the arrangement of the first and second coat drying ovens, the core forming machines and the grinding pans, is illustrated in Fig. 2. After the core bars are pulled, they are deposited on a car operating on a track leading from the pipe foundry to the opposite end of the core shop, where the first coat of core mud is applied. The bars, which are still hot, are picked up by trolley and are conveyed to the core-forming machine for receiving the first coat. The method of handling the core bars is shown in Fig. 14. The first coat of mud has been applied to one bar still on the machine, and after the other bar has been lowered onto extensions from the tops of the supports of the core bar while it is being revolved, the other bar, which has received the first coat, is picked up and delivered to the core oven car. The other core bar is then moved into position and is revolved while turning on the hay. At the spigot end of the core an extra thickness of hay is rolled onto the bar to form the collar which centers the core in the spigot end of the mold. The mud is then rolled onto the hay, the core lifted off and placed on the core oven car, shown on the second track, Fig. 16, which is a view of the cores after the first coat has been dried. The cores are delivered to the other core-forming machine by an overhead trolley, where they receive the second, or finishing coat of mud. The core bar is revolved, as when applying the first coat, and after the mud has been rolled on, blacking is poured onto the core, which is slowly turned to insure a uniform coating over the entire surface. The cores are again loaded onto a core oven car, shown in the foreground, Fig. 16, and are run into the second battery of ovens for drying. After the cores have been dried the car is moved out of the forward end of the oven and the cores are picked up by a crane, as required, and are set in the molds. The crane, which serves the core setting section, has a span of 10 feet, is of 3 tons capacity, and travels the entire width of the shop.

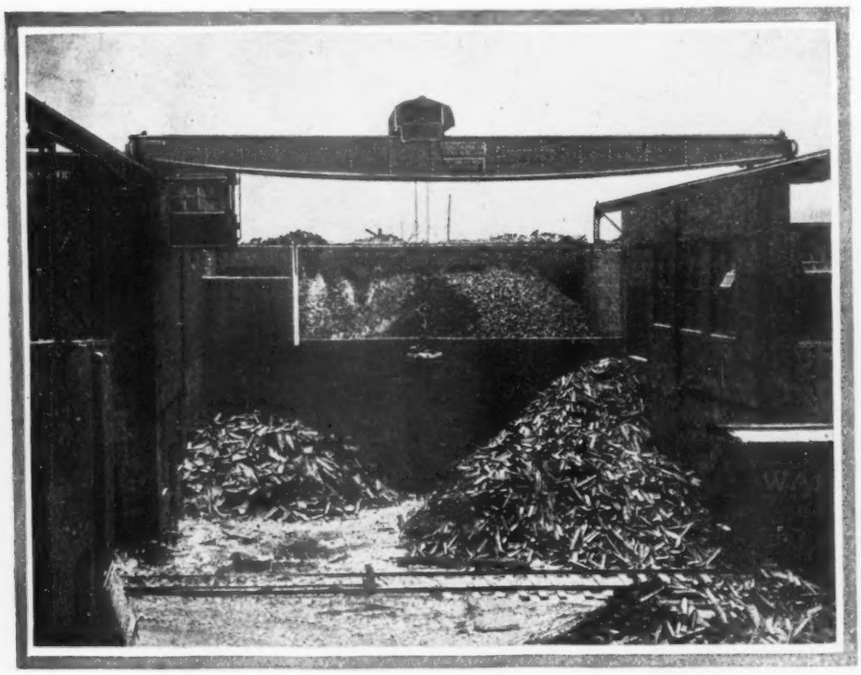


FIG. 19—VIEW OF THE STORAGE YARD, LOOKING TOWARD THE COKE AND LIMESTONE BINS, SHOWING THE RECEIVING TRACK ON THE UPPER LEVEL

Each pipe-making unit is served by two batteries of three ovens, the first for drying the first coat and the second for drying the finishing coat. Twelve tracks for the ore cars are laid through the core shop to the pipe foundry, two tracks passing through each of the first and second-coat ovens. Both ends of the ovens, which are 13 x 16 feet 6 inches, are closed by rolling doors to permit of the uninterrupted passage of the core cars from one end of the shop to the other and through the entire cycle of operations without transferring the

car from one track to another. As the core bars are still hot when the first coat of mud is rolled on, the drying operation is facilitated and the cores remain only 30 minutes in each oven for drying the first and second coats, respectively. At one end of the shop are located two large grinding pans, Figs. 2 and 21, which grind the clay and sand, of which the core mud is made. These pans are driven by individual motors and all operating parts are located above the rolls to protect them from the sand. Adjacent to the grinding pans are sand and clay bins, which hold a sufficient stock for a day's operations.

In addition to the continuous system of making pipe, another economy introduced consists of the utilization of the tar from the producer gas plant for coating the pipe. A sufficient amount is recovered from these producers to meet the requirements of the works. Producer gas is not only used for operating the engines, but serves as the fuel for drying the molds and cores, heating the tar tanks, pipe heating ovens, etc. In the ovens for drying the pipe cores, rows of open-flame burners are located between the tracks, and despite the proximity of the burners to the lower tier of cores, the latter are dried uniformly throughout.

The Clow plant is admirably located on a site of 70 acres, just beyond the confines of the city of Coshocton. With the exception of the office, all of the main buildings are located in a valley, and the natural unloading advantages afforded by a hill overlooking the works were utilized to the fullest extent. To reduce the cost of handling raw materials to the minimum, the receiving tracks were laid on the hill, and coke, coal, limestone, etc., is delivered by gravity to the ground level of the plant. Coke and limestone are dumped from drop-bottom cars into concrete bins, while the coal for the producer plant is similarly unloaded. As originally arranged, the pig iron was to have been unloaded from cars on the hill overlooking the plant, and after making up the charges, the iron was to have been delivered to the storage yard crane to be conveyed to the charging floor. This method of handling the pig metal will be adopted later, and the upper yard will be served by a crane. At present, pig iron and scrap are received over a track extending between the pattern storage and the gray iron foundry, as shown in the ground plan of the plant, Fig. 22, and is unloaded from the cars and is delivered to the charging floor by a lifting magnet. In addition to the continuous cast iron pipe shop, a large gray iron foundry is operated for the production of a wide variety of castings, including cast iron water pipe fittings, drinking fountains, watering troughs, ornamental columns, etc. This foundry is located between the pipe plant and the machine shop. The building is of brick and steel construction, 152 x 201 feet, and is divided into four bays, 25 feet 6 inches; 38 feet 3 inches; 38 feet 3 inches and 50 feet wide, respectively. In the first bay are located two batteries of core ovens, two in each battery, 6 x 15 feet and 7 feet 8 inches high. Another large core oven is located in the other side bay, 12 x 18 feet and 10 feet high. These ovens are all fired by producer gas, with the open-flame type of burners.

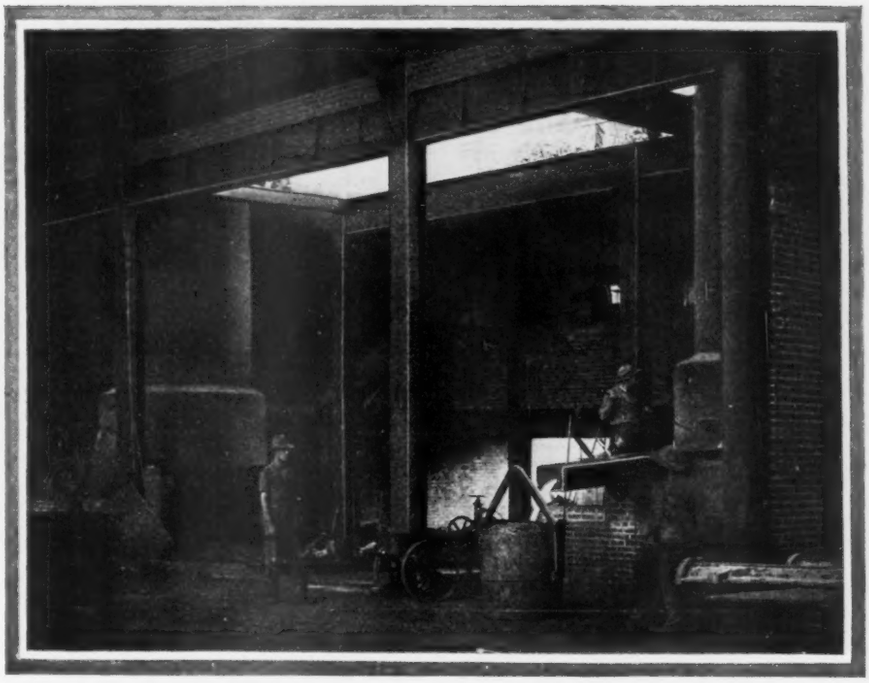


FIG. 20—THE TWO CUPOLAS, SHOWING THE MEZZANINE FLOOR IN THE BACKGROUND

Heavy work is molded in the two middle bays, while in the side bays the lighter castings are made. The molding machine equipment consists of a pneumatic jar-ramming machine, stripping plate machines, as well as a number of squeezers. One of the

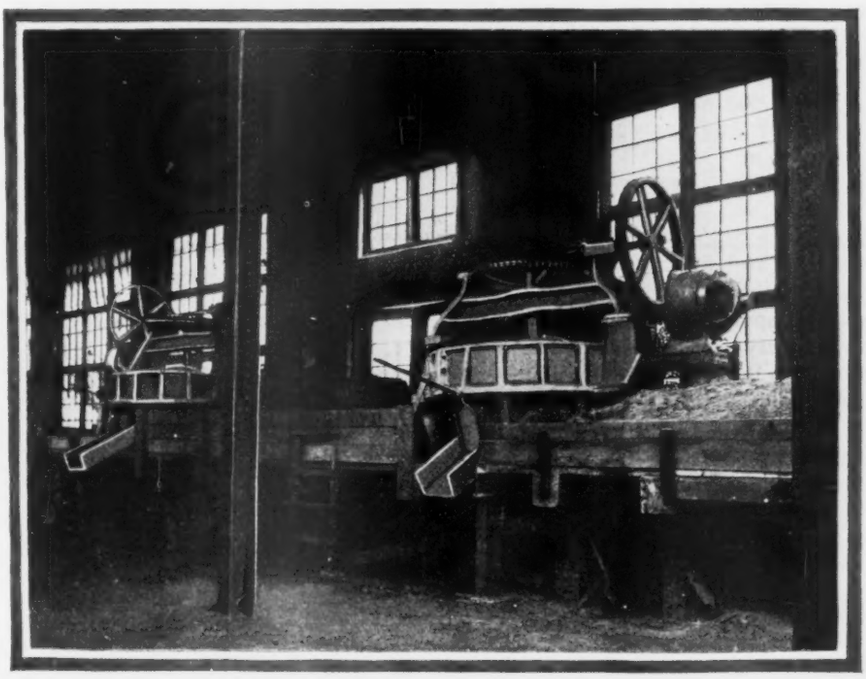


FIG. 21—THE SAND AND CLAY GRINDING PANS

two middle bays is practically an extension of the center bay of the machine shop and is commanded by a 10-ton crane, which serves both departments. Two 5-ton electric traveling cranes command the other middle bay and one of the side bays of the foundry. An industrial track in the foundry is used for conveying water pipe fittings to the tar dipping tank outside of the shop. The cupola shown at the right, Fig. 20, far only two furnaces have been installed, although two additional cupolas will be added, to provide sufficient metal for the pipe foundry. The large cupola at the left is 108 inches in diameter and is lined to 84 inches, while the small furnace is 84 inches in diameter and is lined to 66 inches. The two cupolas to be installed will be 108 inches in diameter, all of the furnaces being of the Whiting type, built by the Whiting

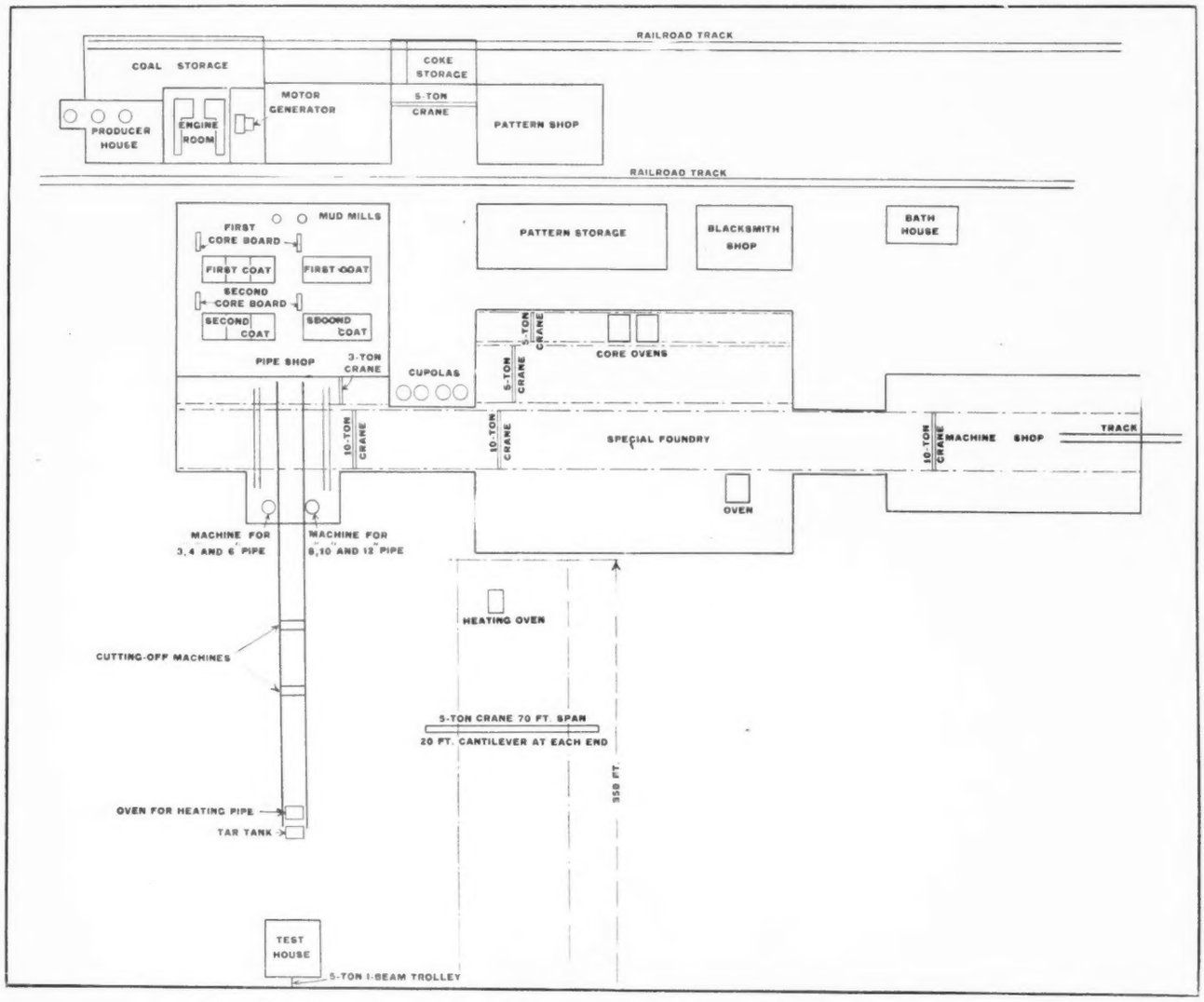


FIG. 22—GROUND PLAN OF THE PLANT OF JAMES B. CLOW & SONS, COSHOCTON, O.

has two spouts, the one extending into the gray iron foundry. The shop is well lighted and ventilated, a monitor extending the entire length of the building, and there are two skylights in the roof over the two side bays, each 40 x 13 feet, while the skylight over the cleaning room is 20 x 13 feet. For facing the molds, cement is successfully used in this foundry, for both light and heavy work.

The cupolas are located between the gray iron foundry and the pipe shop, as illustrated in Fig. 20. Thus Foundry Equipment Co., Harvey, Ill. The blowers are located on a mezzanine floor below the charging platform, and are of the positive pressure type, furnished by the B. F. Sturtevant Co., Hyde Park, Mass. The charging floor, Fig. 18, is 55 x 28 feet, and is served by the storage yard crane. The cupolas are operated continuously, the first iron coming down at about 6 o'clock in the morning, and the blast is not shut off until 4:30 p. m. No difficulties have been experienced from the continuous operation of the furnaces, as they are of sufficient diameter to obviate the difficulties so frequently experienced when operating small cupolas continuously. While ample coke is used, the average melting ratio is 1 to 10, but this would be smaller but for the fact that the coke bed is spread over an unusually large tonnage. The use of cast iron brick, cored out in the center, for lining the cupola opposite and slightly below the charging doors has effected great economies in the cost of lining repairs. Opposite the charging door the lining of a cupola is generally worn away rapidly from contact with the pig iron when thrown into the furnace. The cast iron brick withstands this severe usage and frequently no repairs need be made to this section of the stack in four or five years. The bricks are not melted, as they are located sufficiently high above the melting zone to obviate this. The cast iron bricks are 7 x 3 x 2½ inches, and are laid in fire clay. When charging the borings received from the machine shop, they

are placed in discarded nail kegs and tar is poured over them to bind them together. This method of utilizing this scrap has resulted in exceedingly low melting losses, and the tar provides the cupola with excellent fuel.

The storage yard is 200 x 55 feet, and is located between the cupolas and the concrete coke and limestone bins, as shown in Figs. 18 and 19. The yard is commanded by a 5-ton electric traveling crane installed by the Case Crane Co., Columbus, O. The pig iron and scrap is unloaded from cars by an electric magnet, which also delivers this material to the charging floor. Coke and limestone is loaded directly into charging boxes from the coke and limestone bins, Fig. 19. The lifting magnet was furnished by the Electric Controller & Mfg. Co., Cleveland.

The machine shop, Fig. 22, is 161 x 89 feet, and is divided into three bays. The middle bay is 38 feet 3 inches and is served by a 10-ton electric traveling crane, which also commands the gray iron foundry and the section of the shop in front of the cupolas. A standard gage track leads into the shop to facilitate the loading of the finished product from the gray iron foundry. The building is of brick and steel construction and ample light and ventilation is provided by two lantern monitors, 20 feet long and 13 feet wide, and side lights extending the length of the building. All of the windows are operated by the Pond sash operating device, installed by David Lupton's Sons Co., Philadelphia. The machine tool equipment of the shop is unusually complete and of sufficient capacity to finish the largest castings made in the gray iron foundry.

The power plant is of reinforced concrete and brick construction with steel roof trusses. The engine room is 65 x 45 feet and 20 feet high. The equipment consists of two 250-horsepower gas engines, installed by the Riverside Engine Co., Oil City, Pa., direct-connected to 100-kilowatt Westinghouse generators. Air compressors are attached to the end of each engine and the entire power plant is commanded by a 5-ton electric traveling crane. On the basement level of this building will be located an auxiliary power plant consisting of a 200-horsepower motor generator set which will be furnished with alternating current from the local lighting plant.

The producer house is 48 x 35 feet, with an extension, 15 x 17 feet. It is equipped with three gas producers of 750 horsepower capacity each, installed by the Holbeck Co., Cleveland. The tar recovered as a by-product from this plant is used for coating the cast iron pipe. The coal for the producer plant is unloaded from the cars and is delivered by gravity to the producer house platform.

Adjoining the power plant is the hay storage building, 80 x 50 feet, two stories high and of reinforced concrete and brick construction. The bales of hay are unloaded from cars on the receiving track on the hill overlooking the plant, into chutes leading into the second floor of the hay storage building. On the lower floor are located the hay rope winding machines and the bales of hay, as required, are dropped through an opening in the storage floor to the ground floor level.

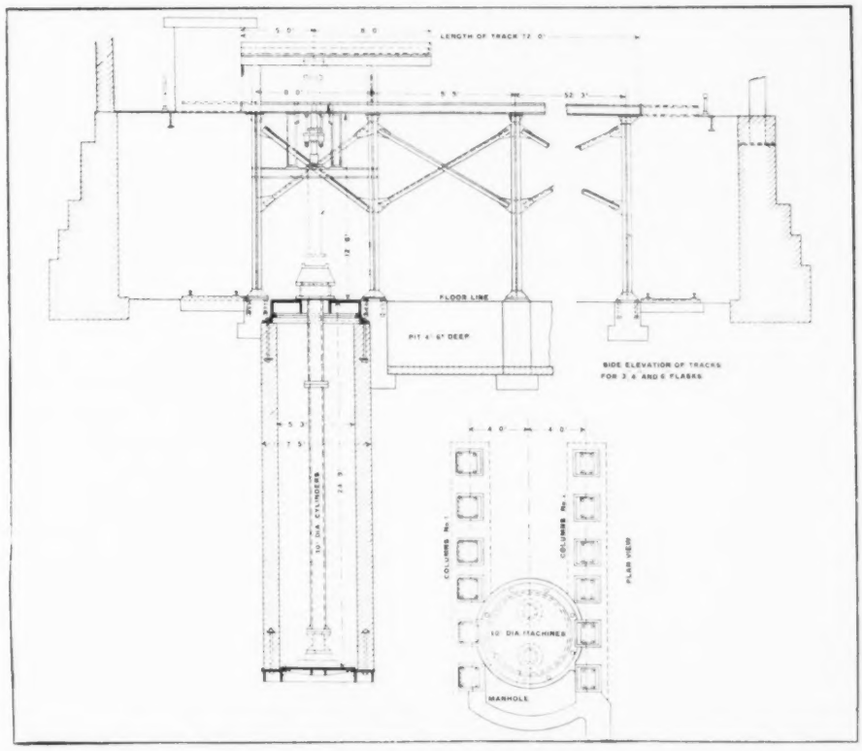


FIG. 23—SIDE ELEVATION OF PIPE MOLDING MACHINE AND SECTION OF RUNWAY

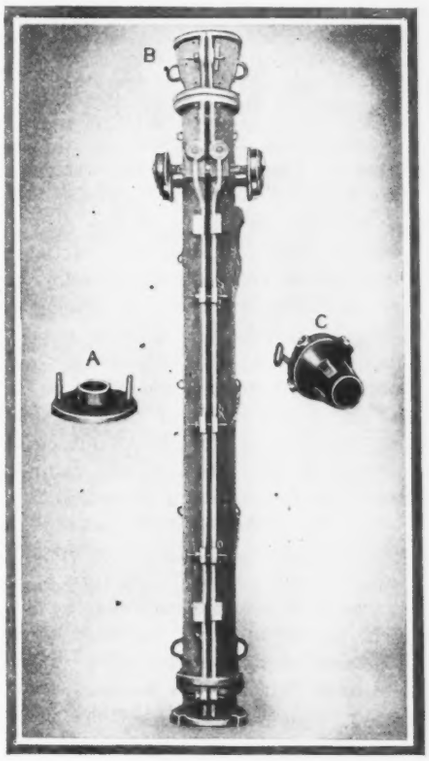


FIG. 24—BOTTOM PLATE, FLASK AND SPIGOT PATTERN

The pattern shop is 80 x 50 feet, of brick construction with the exception of the back wall built into the hill, which is of reinforced concrete construction. The pattern lumber is unloaded from the cars and is delivered to the shop through two chutes leading into the side of the building. The pattern storage is 121 x 41 feet, of brick construction, 16 feet 6 inches high. One end of the building, 20 x 41 feet, is partitioned off for the flask and pattern repair department. The remaining buildings include a blacksmith shop, 61 x 41 feet, and a bath house, 46 x 63 feet, equipped with shower baths and other conveniences for the men.

The entire tract of land on which the works are built is underlaid with molding sand and clay, and all of the sand used in the gray iron foundry and the pipe shop is mined on the property. Side tracks from the Wheeling & Lake Erie and Pennsylvania railroads afford good facilities for the receipt of raw and the shipment of finished materials.

PRODUCTION AND USE OF FOUNDRY COKE

Government report of the coke industry of the United States as related to the foundry--Charging the cupola

In a monograph on "The Coke Industry of the United States as related to the Foundry," issued by the Bureau of Mines of the Department of the Interior, Richard Moldenke briefly reviews the status of the coke industry, some features of practice in the use of coke in the foundry, the probable happenings of a cupola heat and the reasons for modifying charging practice so that a particular coke can be used to best advantage.

In the discussion of the coke-making industry, Dr. Moldenke directs attention to the waste in the manufacture of furnace and foundry coke, which is probably not exceeded in any other industry, unless in the mining of coal itself. Regarding by-product or retort-oven coke, he says that foundrymen are in need of instruction regarding this kind of fuel. He adds that it gives as good results as the best Connellsville coke of the old days, but it must be freed from the prejudice regarding its appearance until the operative forces of foundries are familiar with it, and undoubtedly the excellent quality of the coke produced in some parts of the Connellsville region has been the greatest hindrance to advancement in coke-making.

Methods of Making Coke.

To lay a foundation for the discussion of the proper use of coke in the foundry, the processes and methods of making this fuel are briefly described as follows:

In general, coke is made either by the beehive process, or in the retort or by-product oven. In the former process all the volatile matter is lost in the atmosphere; in the latter the volatile contents, except the gas used in heating the ovens, are recovered as surplus gas, tar, and ammonia liquor or ammonium sulphate.

In either process the quality and structure of the coke produced depends on the original composition of the coal and on the heat treatment it receives. Thus a coal high in volatile matter will naturally make a light, porous coke, the escape of the gases tending to produce such a structure. The yield of such a coal will also be much less than that of a coal higher in fixed carbon and correspondingly lower in volatile matter. Coal of the latter kind will make the denser, heavier cokes, which carry a burden well and are therefore more sought after for melting purposes, other factors being equal. Combination in the by-product oven of the two classes of coal, so as to give an average percentage of volatile matter, will probably get the best general results in the future, for coals of the proper composition can be brought from various sources and can be mixed and run so as always to give the same grade of coke, the mixture doing away with any particular defect the coke might have if made from any one of the coals. A good structure can then be combined in a coke with low sulphur and phosphorus for the blast furnace or with low sulphur and ash for the cupola, and a mixture giving a light, porous structure and a high yield of by-products can be used for domestic coke.

Beehive Coke.

In the beehive oven the slack or ground coal (washed, if necessary, to remove excessive sulphur and slate) is dumped through the orifice in the roof and leveled off to the desired depth. This bed may be thin if 24-hour coke is wanted, thicker if the run is to be normal, and heavy if 72-hour coke, left over Sunday, is to be obtained. Only coke of this last kind is supposed to go to the foundries. They pay for such coke, but as a matter of fact the foundry shipments are composed of coke made in 24, 48 and 72 hours, special care being taken, however, to select the best looking of each kind. Though foundrymen are not hurt in any way by this substitution, as it does not matter how long the fuel was in the oven if it is of proper composition and physical structure, they should be better posted on the coking process, so that if for any reason the brand of coke they regularly use can not be had the introduction of a new one will not demoralize the plant.

The degree of heat, the time of running the oven, and the manner in which the air is admitted, of course, have a great effect on the physical structure, and where the longest time is allowed for making coke the results are apt to be best for foundry purposes. Thus, during the depression at the close of 1907 many ovens in the West Virginia coke districts were run with heavy charges, the heat lasting a whole week. The purpose was simply to keep the ovens hot and make little tonnage. Yet the coke turned out to be exceedingly hard and still of excellent structure for melting purposes. On the other hand, where ovens are hardly given time to complete the coking process the product is necessarily soft, will be high in volatile matter, and inferior even for the blast furnace.

The effect of heat treatment is even more noticeable in the retort oven. Here the coal, in properly ground form, is dropped into the large retorts or chambers and occasionally is stamped in, or it may be pressed into cakes and forced in from the end. The oven is tightly closed, the heat being supplied through flues in the walls of the oven. The by-products are rapidly given off, practically all of them being recovered during the first two-thirds of the process. Where recovery of these by-products is the primary object and the quality of the coke is a secondary consideration the ovens are drawn as soon as the point of greatest economy has been reached, sometimes in 15 hours; the result is poor coke, as many blast furnacemen have found, and the result has been a prejudice against retort-oven coke. Where, however, coking is continued for the full 24 hours, or even for 30 hours, the coke is of very good structure, provided it has had proper attention and the coal mixture is right.

Consumers of retort-oven coke should therefore make sure that their interests are regarded where it is produced; such insistence has, in fact, so worked out that, particularly in the interest of foundries, certain by-product plants in this country are run on mixtures of coal and under heat conditions that leave nothing to be desired.

Adjustment of Practice to Fuel.

In discussing cupola practice, Richard Moldenke calls attention to the difficulties so frequently experienced in melting iron and adds that much trouble could be avoided by changing the melting program to suit the fuel that is used. This subject is discussed in the report, in part, as follows:

Normal coke has 50 per cent cell space and has, pound for pound, practically double the volume of anthracite. Hence during the melt the downward movement of the metal within the range of the melting zone must be twice as fast when coke is used as it is with anthracite. Therefore, the difference between the first of the metal to melt and the last, with respect to the influences to which they have been exposed, is greater for a bed of coke as compared with a bed of anthracite, of like weight. That is, the first metal to melt is likely to be the same on either the coke bed or the bed of anthracite, but the last metal, especially if the charge is very heavy, melts much lower down in the coke-charged cupola and is necessarily subjected to greater oxidizing influences, because the blast low down in the cupola contains more free oxygen. When anthracite is used the part of the bed where the melting is actually done varies least in position.

This advantage is still retained by many foundrymen in the east, where anthracite, as it is still available and

no dearer than coke, may be used for the fuel bed and often mixed with coke in the subsequent charges, or even used altogether.

A study of the downward movement of the metal, as just stated, is important, as it suggests the way to make use, in regular casting practice, of practically every variety worthy of the name of foundry coke. Anthracite and coke, being practically identical in composition—that is, containing the same percentage of ash, fixed carbon, sulphur, etc.,—differ radically only in physical structure. Thus, if the cell space of a coke is 50 per cent, as mentioned above, the coke has twice the volume of an equal weight of anthracite. Now, not all cokes have the same cell space, and, moreover, cokes differ in percentage of ash, etc. Hence a given weight of coke varies greatly in volume, and consequently the behavior of charges of iron melted with it also varies. The foundryman when changing his brand of coke makes the mistake of believing that the new kind ought to be handled in the same way as the old. It may be possible to do so if the two cokes have the same characteristics, but if they have not, the foundryman is certain to get differences in results, which he usually ascribes to sulphur, black ends, and what not. His coke dealer then hears from him. This difficulty is so marked that even when the same brand of coke is bought the year round and trouble results, investigation of the shipments often reveals substitution of coke from different companies located in the same general region.

It is therefore highly important that the foundryman get his coke from the same ovens and the same coal mines—in fact, have it as nearly the same as it can possibly be made; if a change is desirable or necessary he should be informed, so that he can adjust his work to the changed conditions.

Coke Tests at St. Louis.

The tests of cokes, made from coals mined in all sections of the country, made in St. Louis several years ago, are briefly reviewed as follows:

In all about 190 tests were made. Three thousand pounds of metal were melted in each test. To have uniform conditions in the coke bed for each test and at the same time to suit the average coke made, the height of the bed above the tuyeres was fixed at 14 inches as the standard, and this height was kept for every test. The upper tuyeres of the cupola were not used. A melting ratio of 7 to 1 was adopted, as the diameter of the cupola was small. The coke for the bed was weighed and put in up to the proper point, as measured by a weighted wire. The weight of the several cokes for this constant bed varied from 180 to 230 pounds, showing a considerable range in specific gravity—from the very light to the heavy cokes.

Metal weighing four times this weight of coke was charged on this bed, to conform to the general custom of foundries, and the remaining successive charges of metal and coke were divided into four parts, so as to preserve the total ratio of 7 to 1, the coke charges varying from 50 to 62 pounds and the metal charges correspondingly.

The blast was kept at about 7 ounces, and the time when the first iron appeared at the spout was noted. This time, which was five to fifteen minutes, was interesting as indicating how the coke behaved in burning and in allowing the iron to come into the melting zone. With the best results the iron came in seven to ten minutes.

Necessarily for the extremely light and very heavy cokes such melting practice would mean disaster, and in fact the melting loss did point very markedly to such a result. Possibly this may also convince many foundrymen who still think it impossible to burn up iron in the cupola. The results showed the melting losses to be from 3.2 to 52.5 per cent of the metal charged. The cupola was continually slagged off, but in the worst case so much slag was made that it flooded the tuyeres and effectually stopped operations. When the bottom was dropped no metal was found remaining. It was evident that the lighter varieties of coke burned away so rapidly that the metal came to the lower portion of the melting zone much faster than it should have come. Moreover, as the original bed went down unduly for the melting of the first charge the subsequent coke charges did not bring the bed up to proper level again, and hence a Bessemerizing of the metal took place almost from the very beginning.

In tests of the very heavy cokes it was necessary to wait a good while before the bed had burned low enough to begin melting. Necessarily at the fixed ratio of 4 to 1 the first charge of metal on the heavy coke bed was very heavy. In this case also there was an undue lowering of the bed by the heavy metal charge after the surplus coke had burned off to begin melting. What was worse, however, was that the heavy coke bed took so large a part of the total amount to be used that the upper coke charges were necessarily very small, and the practical result was not only burned metal, but an insufficient amount of coke toward the end to continue the heat, so that the bottom had to be dropped. The general result of these heats with very heavy coke was burned iron for the beginning and unmelted iron in the cupola drop.

It may be seen, therefore, that when the melting process with a normal coke gives good results it does not necessarily follow that every other coke will do likewise; yet this is what the foundryman practically assumes when he changes his coke without making trial heats to see how to use it.

Value of Melting Tests.

Perhaps the custom that is just beginning to be introduced into this country by coke companies of sending out experts to teach foundrymen to use their particular brands of coke may obviate many of these difficulties. The retort-oven coke people were simply forced to adopt this plan, the appearance of their coke being so bad, as compared with the magnificent Connellsville product, that it took great argument to sell it at all. It should be understood that the clean, silvery appearance of beehive-oven coke as compared with the dull black cast of the retort oven product results principally from the manner of quenching. In the beehive the quenching is done within the oven, and as little water as possible is used. In the retort oven the red-hot charge is forced out and deluged with streams of water as it drops into the receptacles for the coke.

Coke producers should, therefore, be urged to make thorough melting tests with their coke, so that when selling it they can advise foundrymen how to get the best results with it. This plan would save enormous trouble, as there are about 6,500 foundries using coke in the United States and Canada, and but a very small percentage know how to make comparative tests of coke and draw conclusions therefrom that will guide them in its proper use. There are, on the other hand, comparatively few coke producers, or selling agents for coke producers, and it would pay these firms well, to have a central testing station, or a sort of "trouble bureau," for coke tests.

Burned Iron in the Cupola.

In introducing this subject, the author states that not only in the cupola, but in every other melting process, this subject is now better understood. In the cupola, if the metal is oxidized even slightly, its melting point is raised, and it will drop more sluggishly and will receive more damage from the blast farther down. Practically all defects in castings such as pin holes, excessive shrinkage, draws and cracks can be traced back to burned iron and when steps have been taken to correct the cupola practice, these troubles have disappeared. The following discussion of these defects is included in the report:

Pin holes are due, not to the inability of the air to get out of the molds fast enough, but to the yielding up of dissolved gases in the iron at the moment of set. The first thing that happens in the mold, if the iron poured is not much overheated, is the setting of a thin skin of metal against the sand, and hence these gases in going upward and outward to escape strike the thin shell that has set and stay there. When the casting is put on the planer and the skin is removed the pin holes make their appearance and the casting is condemned. Such an outcome is particularly annoying with respect to fine varieties of rolls, on which an unblemished surface is absolutely necessary. When the metal is badly burned, as, for instance, in low-silicon heats for malleable castings, the

formation of gas is so strong that the casting is honeycombed, not with pin holes as in the high silicon iron, but with blowholes ½ inch across, and the interior surface is black from oxidation.

As a further difficulty, if the metal is oxidized, even very slightly, its melting point is raised considerably, so that it readily freezes or, as the foundryman has it, loses its "life," and the ladles "skull." As a consequence, in pouring the gates freeze up and the castings are short-poured. If the casting has been poured, the molten metal may be cut off so quickly that interior shrinkages are more than likely to occur, as no feeding can take place.

Finally, burned metal is very weak. It seems as if a coating of oxide gets between the several crystals, so that their tenacious grip on one another is lessened. Hence casting strains find the metal unprepared to resist and a crack is the result.

A little oxygen can do an immense amount of damage. The very worst burned iron ever seen by the writer contained only a few hundredths of 1 per cent. The evils of high sulphur are as nothing compared to it. Hence only a very small amount of aluminum or titanium is necessary to make the correction, more than 0.1 per cent seldom being required for addition to the ladle to produce the desired deoxidation.

Cupola Charging.

Regarding the actual processes in the cupola, Dr. Moldenke says that the foundry trade is still in the dark, and until means are provided to take temperatures accurately, as well as samples of the gases formed at every point within the active part of the working end of the cupola, only theories of the melting process can be advanced. The depth of fuel bed is discussed as follows:

All melting occurs above the tuyeres, for the blast can find an exit only up the stack. The coke below the tuyeres is therefore only a filling and serves no other purpose, as it is not even so hot as the molten iron that collects around it before being tapped. The tuyeres are placed high or low, as the the exigencies of the shop may require. Where a continual stream of very hot metal is wanted, as, for instance, in light casting work or in the molding of stove plate, the tuyeres are placed about 6 inches from the bottom and the coke filling is least in volume and height. For melting pig iron before it is Bessemerized for steel the tuyeres may be a few feet above the bottom, because a rather large tonnage of metal has to be kept between blows. In European practice the forehearth does the work of a deep crucible in the cupola, serving as a big ladle or catch-basin for the molten metal running unchecked out of the cupola spout. The forehearth, however, is intended to be heated as part of the blast arrangement; but unless the regenerative system is used it is doubtful whether high enough temperatures are obtained to do this heating to any considerable extent. The proper method would be to use a mixing furnace, such as may be seen in steel practice. This is merely a tilting open-hearth furnace, in which the metal is kept continually up to the proper temperature.

Between the least and greatest depth of the bed below the tuyeres there are of course depths adapted to various classes of work, some foundries preferring a height of 20 inches between the bottom and the tuyeres and others 14 inches, 10 inches, or whatever height gives them the space they want for the storage of metal. The quantity of coke thus used, especially in small heats, naturally affects the melting ratio; if this fact is forgotten and a high ratio is arbitrarily selected, the heavy bed often leaves too little coke for the upper charges, as, for example, in the tests at St. Louis with heavy cokes. In long heats this factor is not so apparent.

Small Charges.

The portion of the bed above the tuyeres is next to be considered, where the actual work of melting is done. The cold air entering the cupola at once attacks the coke and delivers up its oxygen, which, by the time it is all consumed, has traversed a certain distance inward and upward. This distance probably limits the melting zone, the shape of which no one can tell until experiments such as were referred to have been made. The effect of this zone is seen along the lining, and the more defined and the narrower it is the better are the results. If the zone, as shown by the cutting action on the lining, spreads over a considerable height, the melting is irregular. The lining should be fairly clean throughout, easily chipped out, and quickly daubed up, otherwise practice has been defective.

This melting zone may be in the shape of a parabola flaring upward along the sides or, if Mr. West's center blast is used so that the blast pressure is more nearly equally distributed, its upper limit may approach a flat plane; in either case the highest temperature is reached at a point somewhat above the entry of the air, and above that point the heat diminishes. It is in the melting zone that the reaction between the oxygen of the blast and the carbon of the coke bed is most intense, and it is here, probably, that the formation of carbon dioxide is greatest. Here, too, the cupola temperatures reach a maximum, probably about 3,500 degrees Fahr. Below the narrow limits of the melting zone the temperatures are less because the combustion of the carbon, its reaction with oxygen to form carbon dioxide, is incomplete. Above the melting zone the temperature falls because, if the coke bed is thick enough, the carbon dioxide formed in the melting zone has to pass the rough incandescent fuel, and the glowing carbon reacts with the carbon dioxide to form carbon monoxide, the gas that may be seen burning in the upper part of the cupola. This reaction takes up heat, and hence within a distance of 3 feet, if the coke bed is so thick, the temperature falls to about 2100 degrees Fahr.

Thickness of Coke Bed.

It is evident that if the thickness of the coke bed is so proportioned that all melting takes place within the melting zone, the melting will be done quickly and well, as the melting point of the iron ranges between 1,900 and 2,400 degrees Fahr. If, however, the coke bed is excessively high, some iron will begin to melt as soon as the coke bed has burned away enough to bring the temperature to the melting point, and will then melt slowly. As a result, cold metal will drop into the crucible of the cupola, causing the many annoyances of cold metal in pouring. The best economy is naturally had if the metal is just at that point of highest temperature, and not much below or above it. As the heat progresses the coke is rapidly burned away. Hence the bed is lowered and the metal sinks; the next charge of coke is intended to restore the bed to its original height so that each successive charge of metal may melt in the same position in the cupola. Under the best conditions the lower part of the metal charge melts in the upper part of the melting zone, and the upper part of the metal charge melts in the lower part of the melting zone. Hence if a metal charge is too heavy some of the iron is melted below the normal limits of the melting zone, and if a charge is unnecessarily light all the iron is melted in the upper part of the melting zone. If each charge melted at the same level there would be no more to say on the subject; and the fact that it did happen in former times, when no attempt was made to charge in layers, shows that perhaps we have not progressed so much as we suppose.

If, as there is reason to believe, the melting is best done at the point of highest temperature, the point at which the last portion of the usual heavy first charge of iron must melt, is considerably too low in the cupola, owing to the sinking of the bed, and the metal. The heat may be high enough there, but the gases in the cupola near the tuyeres are not yet free from uncombined oxygen. As a result the metal must suffer somewhat by contact with this free oxygen at so high a temperature. If this statement of conditions is in any degree true, the remedy is to make the charges as small as possible, so that the fluctuation in position of the effective part of the coke bed may be as slight as possible, and the cutting action in the cupola limited to a height of a few inches instead of feet.

Uniform Charges.

Inasmuch as only the very top of the coke bed is effective for melting without oxidation if it were correctly made at first, the question arises why is it the prevailing practice to make the first lot of metal several times as heavy as those succeeding. The obvious reason is plausible enough at first glance—namely, that a lot of metal ought to go on top of a lot of coke in the bed. It is forgotten

how little of that big bed of coke really does the work of melting.

The damage caused by large first charges of iron may best be shown by figures. Let us assume that every 1,000 pounds of iron in melting uses up 1 inch of coke bed. If the first charge of metal is 6,000 pounds, 6 inches of the coke will have been burned away when the metal is melted. If iron is really damaged by oxidation, the last 3,000 pounds of that charge is not quite so good as the first 3,000. Now, the first intermediate charge of coke comes down. Does that restore the 6 inches of the bed? By no means. It is merely enough to melt the next and much smaller charge of metal. Let us say it restores the bed 3 inches and disposes of a succeeding charge of 3,000 pounds of metal. The bed, restored only halfway up to its original position in the melting zone, burns down 3 inches again in melting the second charge, nearly all of that iron being melted at a point where it is affected by unconsumed oxygen in the blast. This restoration and melting is repeated until the end of the heat, and the practical effect of the big first charge is to give an inferior grade of iron for the entire heat, unless extra coke between the charges brings the bed up to proper level.

Many foundrymen have recognized this point, and now run their cupolas with charges of metal alike from first to last. But if there is any advantage in keeping the fluctuations of the bed uniform, there is additional benefit in making this fluctuation as small as possible.

Adjustment of Bed.

The bed must be of the right height to start the melting properly; otherwise all subsequent care is useless. Many foundrymen have adopted the method of melting by small charges, most of them successfully from the start, but others have not succeeded until attention was called to the height of their bed. Practically the only way to know when this height is right is to observe the time between "blast on" and "first iron." Every foundryman knows that when this time is about seven to ten, preferably eight, minutes he gets his best results. So in determining the right height of bed, if iron comes at a time within these limits it is safe to continue to charge the heat. If the iron comes, say, in 15 minutes, the bed is too thick; if it comes in four or five minutes, the bed is too thin. Thus this matter can be attended to at first. In a new cupola the bed can purposely be made too thick in the first heat and reduced subsequently until the proper time of "first iron" is reached. This "first iron" means the first metal running continuously just previous to "stopping up," and not the few random drops that often come in five minutes. Where in practice the tap hole is closed when the blast is put on, it had better be left open, for a few days, until the action of the cupola in this respect is known.

In making the estimate of the correct time from "blast on" to "first iron," it was assumed that the charging was done on a fuel bed well burned through, with all the wood consumed. The writer has noted instances in which about a third of the bed coke was put on and burned through. Then the remaining two-thirds was added, the cupola charged, and the blast turned on. In such instances the first few minutes of the observed time to "first iron" were taken up by the fuel bed burning through and did not form any part of the melting time. Iron in eight minutes was really iron in four or five minutes, consequently the results were disappointing.

Thick and Thin Beds of Coke.

Too heavy a bed has nearly as bad an effect as one too thin. The thin bed, as has already been explained, has just the same effect as a very heavy first charge. The entire process of melting throughout the heat takes place too low down and in a more or less oxidizing atmosphere. If the intermediate charges of coke used were not as a rule slightly heavier than necessary, thus causing the fuel bed gradually to rise, a low bed together with a heavy first charge of metal would give serious trouble throughout the heat. As it is, these conditions may account for much of the badness of the "first iron," commonly laid altogether to sulphur.

On the other hand, too thick a bed unduly delays the metal. The bed has to burn away, and while it burns some of the stock melts slowly too high in the cupola and hence is exposed too long to the influence of the cupola gases. The melting is therefore slow, and the iron may be slightly burned and is apt to be cold. Slow iron nearly always means inferior iron. The evils of too heavy initial charges are perhaps most noticeable in air-furnace and open-hearth practice, where a slow heat is an abomination.

If the bed is too thick, a heavy first charge of metal keeps the succeeding charges of iron from melting too high in the cupola and reduces the danger from burned iron. The writer, indeed, has observed a number of instances of excellent results obtained, with a thick bed and heavy first charge, with very small intermediate charges. Such practice does not seem good, however, as some of the "first iron" will be dull. Better have a proper bed and uniform charges.

In changing from the current practice of high fuel bed and heavy initial charge of metal, it will be noticed that a little while after the start the melting always becomes slower; that is, of course, if the same ratio of coke to iron is used for the intermediate charges in the two methods. This is because some of the coke which was used up under the old conditions to make slag and cut the lining becomes available for melting, less fuel is needed, and the fuel bed rises. This thickening of the fuel bed and slow melting is easily remedied, when observed, without doing harm anywhere and with a saving of coke by changing the melting ratio; that is, cutting down the intermediate coke charges slightly.

It is but natural that the system of cupola charging above outlined, which has been before the foundry public for several years should have been tried out by many foundrymen with varying success. Among the hundreds of instances of trials in large and in small cupolas that have come to the attention of the writer, whenever failures or indifferent results were reported, investigation always indicated something wrong with the bed charge, or a lack of care in the charging itself. Melters object to the extra labor of weighing out small charges, preferring their comfort to clean, sound iron. In some instances, indeed, melters have deliberately added extra coke in order to show that melting became slower by the small-charge method. However, no matter what the cupola or what the class of castings made, a reduction in the size of the charges always works to advantage, and wherever slower melting has been noticed a slight reduction in the intermediate coke charges has always restored the proper rate of melting. Naturally, it takes more care to get an even distribution of small than of large charges, but the reduction in scrap castings is surely worth some effort.

Burned Irons.

Again, it does not follow that burned iron always results from very heavy charges. When the conditions become such that the molten iron is attacked by oxygen, the iron may be protected by the manganese in the charge. Silicon gives similar but less protection. The foundryman merely has to remember that when the metal is slightly too low in the melting zone of the cupola the same conditions obtain, though in far smaller degree, as in the Bessemer process, in which manganese, silicon, and carbon, and with them more or less iron, are burned out. What the foundryman should look to is that his cupola does not become a sort of converter during any part of the melt.

In conclusion, it may be said that the logical method of cupola charging after the bed is in would be to do away altogether with separate metal and coke charges, and yet keep the proper ratio of iron to coke. This ratio can be maintained by weighing out metal and coke in separate piles on the platform and charging a small quantity at a time from each pile, after the manner of proportioning sand and facing materials. The claim has been made that this method, the one used by our foundrymen forefathers, means slower melting, but careful trial has shown that such is not the case. However, the discomfort and cost of the method will preclude its use.

The writer has advanced another suggestion, that to reduce the cost of charging a cupola to a minimum the charges should be made up in the yard. They should be carefully laid in special charging buckets with swinging bottom doors to drop the charges exactly as laid. If the cupola is cut off at the platform, one man in the yard with a reversible hoisting engine and a revolving jib crane can handle the charges. This plan has been tried at a large foundry

with excellent results. A suitable hood and stack above the cut-off cupola will carry off escaping gases.

Coke Districts of the United States.

Discussing the coke districts of the United States, Dr. Moldenke says that coal-washing methods have now progressed so far that it is possible to make very creditable foundry coke out of coal that was formerly considered too poor material for blast furnace coke.

Analyses of coke made in various districts follow:

Average Analysis of Alabama Coke.

	From run-of-mine coal, per cent.	From washed slack, per cent.
Moisture	1.34	0.75
Volatile matter	1.03	0.75
Fixed carbon	83.35	86.00
Ash	14.28	11.50
Sulphur	1.30	0.90

Average Analysis of Colorado Coke.

	Per cent.
Moisture	0.44
Volatile matter	1.31
Fixed carbon	82.18
Ash	16.07
Sulphur	0.44

Range of Composition of Pennsylvania Cokes.

	Per cent.
Moisture	0.23 to 0.91
Volatile matter	0.29 to 2.26
Fixed carbon	92.53 to 80.84
Ash	6.95 to 15.99
Sulphur	0.81 to 1.87

Range of Composition of Tennessee Cokes.

	Per cent.
Moisture	0.22 to 1.67
Volatile matter	0.11 to 1.60
Fixed carbon	92.44 to 76.87
Ash	7.23 to 19.86
Sulphur	0.61 to 2.45

Range of Composition of Virginia Cokes.

	Per cent.
Moisture	0.16 to 1.52
Volatile matter	0.80 to 1.67
Fixed carbon	93.24 to 88.52
Ash	5.80 to 8.29
Sulphur	0.42 to 1.02

Composition of a Washington Coke From Unwashed Coal.

	Per cent.
Moisture	1.02
Volatile matter	2.10
Fixed carbon	77.53
Ash	19.35
Sulphur	0.44

Range of Composition of West Virginia Cokes.

	Per cent.
Moisture	0.07 to 0.60
Volatile matter	0.46 to 2.35
Fixed carbon	95.47 to 84.09
Ash	4.00 to 12.96
Sulphur	0.53 to 2.26

Standard Coke Analysis.

In conclusion Dr. Moldenke suggests the following standard specifications for foundry coke:

	Per cent.
Moisture	0.50
Volatile matter	0.75
Fixed carbon	89.75
Ash	9.00
Sulphur	0.70

A standard analysis of this kind should prove valuable for purposes of comparison to foundrymen making coke purchases, and Dr. Moldenke hopes that standard coke specifications will some day be prepared that will prove acceptable to all interests concerned.

Henry E. Pridmore

A settlement of the estate of the late Henry E. Pridmore, Chicago, was recently effected and the molding machine business conducted under his name is now owned and will be carried on by Mrs. E. M. Pridmore and son, H. A. Pridmore. The firm name, Henry E. Pridmore, will be retained and there will be no change in the conduct of the affairs of the concern. The mechanical and sales organizations will remain practically unchanged and R. E. Turnbull, who has been associated with Henry E. Pridmore for many years, will, in addition to his new duties, continue to represent the firm in the central west. D. F. Eagan, whose headquarters are in Boston, will continue to represent Henry E. Pridmore in the New England states and eastern New York. Wm. H. Phinney, whose headquarters are in Philadelphia, will continue to represent the firm in eastern Pennsylvania and throughout the southern states. A. V. Magnuson, who will be the plant superintendent, was associated with Henry E. Pridmore since the establishment of the business and has been a prominent factor in the development of the Pridmore labor-saving molding appliances.

Cupola Malleable

By Richard Moldenke

Question:—We would like to melt malleable iron for light castings in a cupola and wish to obtain the following analysis: Silicon, 0.90 per cent; manganese, 0.40 per cent; phosphorus, 0.10 per cent, and sulphur, below 0.10 per cent. The problem confronting us is the operation of the cupola to produce metal to conform to this analysis.

Answer:—To produce this metal in the cupola it will only be necessary to have the average silicon of the mixture 0.25 per cent higher in silicon than is desired in the casting, or 1.15 per cent. The manganese, which at 0.40 per cent is high, you will find advisable not to have over 0.60 per cent in the mixture. The phosphorus must not average over 0.09 per cent and the sulphur should be as low as possible, at the highest it should not run over 0.05 per cent in the mixture. So far as the operation of the cupola is concerned, you should make your coke bed high enough to get the first metal in 8 to 10 minutes after putting on the blast. Your bed should be thoroughly burned through and the first charges should be well heated. Make the charges as small as you can and have them well mixed, so that the stream of metal may be uniform. As the heats made in the cupola are usually small and a fair amount of metal is held, the melting ratio is generally very low, in usual practice 1 to 4. With larger heats the melting ratio is, of course, much better, but plenty of coke should be used so that hot iron will be obtained. In cupola practice it is essential that you begin operations right and for this reason care should be exercised in making and burning the bed.

Chilled Rolls

By N. W. Shed

Question:—What are the chief essentials in making chilled rolls for cupola iron? Upon what factor does the hardness of the chill chiefly depend? Upon what does the depth of the chill depend? How can we avoid an intensely hard skin, too hard in fact to tool?

Answer:—The chief essential in making chilled rolls is to have a low silicon, low phosphorus pig iron and to melt hot. Scrap may be used to some extent. Some makers use 50 per cent, but the scrap should analyze about the same as the pig iron and should not be excessively high in sulphur. The chill depends principally upon the amount of silicon present, but the presence of sulphur increases the chill and usually makes the chill harder. An intensely hard chill is generally due to high sulphur and low manganese. If the manganese is increased to 1 per cent, the chill will not be so hard. The increased amount of manganese removes some of the sulphur, which is the chief cause of producing the hard skin. The surface of a chilled roll will resist heat better if the manganese is high. The chill produced with high manganese and low phosphorus iron extends more deeply into the underlying gray iron, while a chill produced with low manganese and high phosphorus shows a sharp line where the chilled portion meets the gray iron. Steel scrap is now used quite extensively in making steel rolls. It has a tendency to lower the total carbon and the chill produced is not quite as hard as a high carbon chill would be. About 15 per cent of steel with car wheels and low silicon pig iron makes a good mixture. Charcoal iron is used, to a large extent, in making chilled rolls of the hard type. The chill is usually regulated by the silicon, keeping the silicon and phosphorus low for a deep chill. The silicon content should be about 0.50 per cent and for a light chill about 1 per cent. The sulphur should be under 0.08 per cent; the phosphorus, 0.30 per cent; and for most work the manganese should be over 0.60 per cent.

JOB SHOP FOR LIGHT STEEL CASTINGS

Description of the plant of the West Steel Casting Co., which specializes in the production of converter and crucible steel castings

ALL branches of the steel casting industry have shown marked advances in practice in recent years, and one of the most interesting developments is the tendency toward specialization, not only as to the size of the castings, but as to the quality of the output as well. The present generation of foundrymen can well recall the time when the gray iron foundry would undertake anything in the casting line from stove plate to the largest engine bed, and while the jobbing shops, today, do a wide variety of work, their output is largely limited to light, medium and heavy castings, respectively. The equipment required for light work is entirely unsuited for the production of heavy sections, and the difference in the shop arrangement, sands and other supplies, has led to the development of so-called specialty shops, for the most economical production of gray iron castings.

The need of specialization in the steel casting industry is, by far, greater than in the gray iron trade. The three processes of steel manufacture—open-hearth, converter and crucible—naturally divide the output into heavy, medium and light work, yet, only too frequently, the open-hearth plant will undertake the manufacture of light castings, for which the shop equipment is not only unsuited, but the nature of the metal is such that the castings can only be successfully produced after repeated trials accompanied by heavy losses. The difference in the fluidity of the metal, made by the three processes, is a factor of prime importance, and the sluggish metal for heavy work is not adapted for light castings. Furthermore, there is a marked difference in the cleaning equipment required for large and small sections, and as this cost is one of the largest items of expense in steel casting manufacture, it is essential that the greatest possible economies be effected in the cleaning department.

All of these factors were carefully considered by the officers of the West Steel Casting Co., Cleveland, prior to the erection of their plant, and after a careful survey of the market, it was concluded to make a specialty of medium and light castings, for which there appeared to be a good demand in the district in which the shop is located. The plant was designed and the melting equipment, consisting of a converter and crucible furnaces, was installed with that end in view. To insure economy of production, not only has modern equipment been provided, but methods of manufacture have been adopted that reduce losses to a minimum. It is well known that metal from bottom-pour ladles insures cleaner castings than when poured by the tea kettle or over-the-lip method. Appreciating the great advantages to be derived from bottom-pouring, it was decided to adopt this method for the converter steel produced. To insure the proper fluidity of converter metal for pouring light work it must be produced at a higher temperature than open-hearth steel. The searching tendency of exceedingly fluid converter steel makes

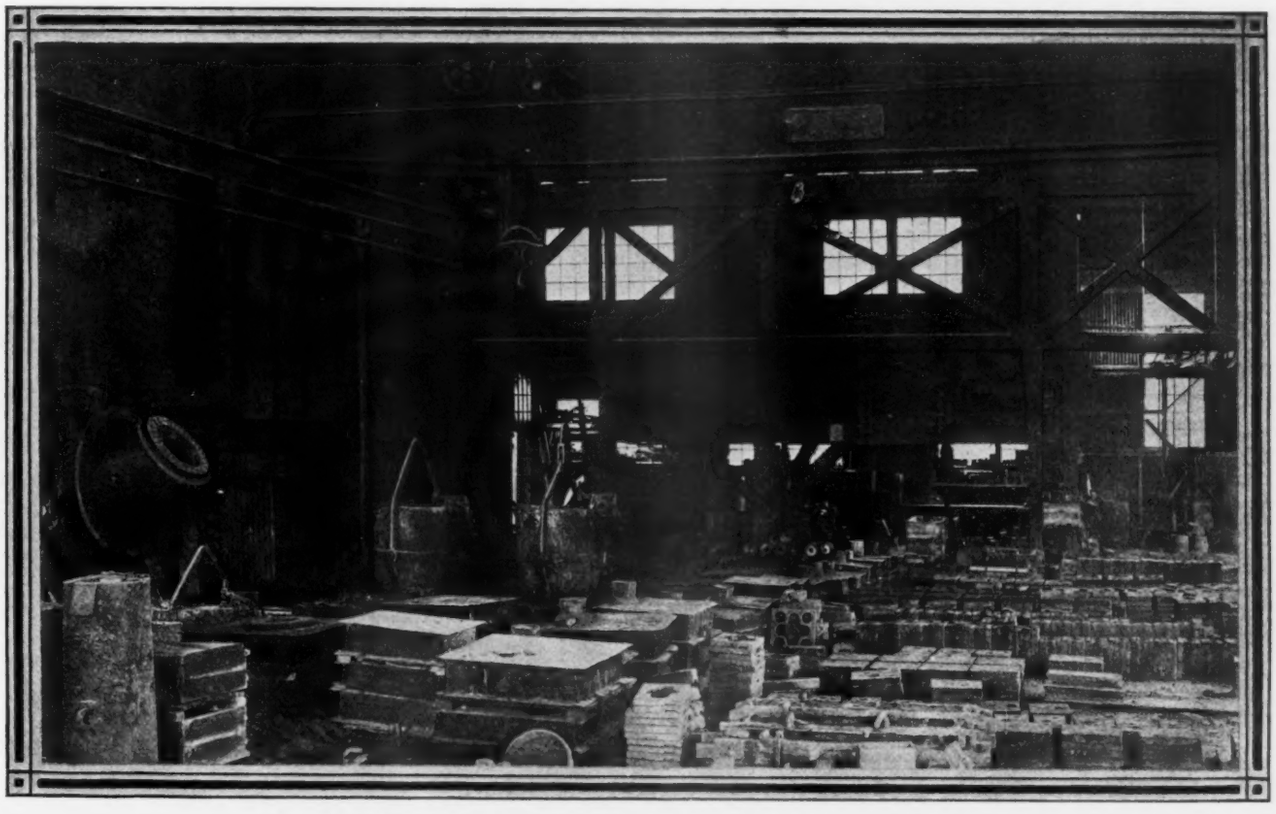


FIG. 1—VIEW OF ONE SECTION OF THE WEST STEEL CASTING CO.'S FOUNDRY

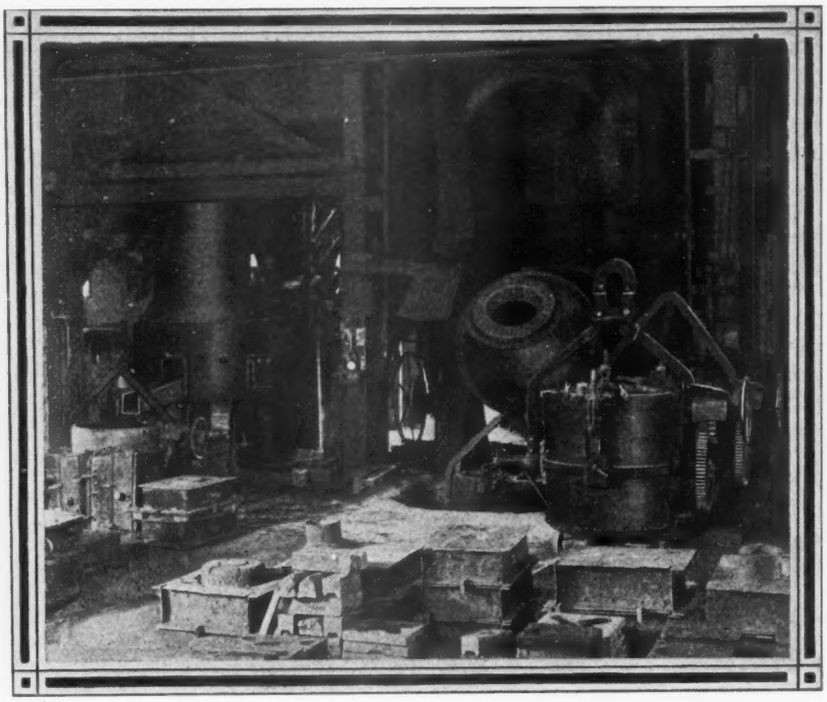


FIG. 2—ARRANGEMENT OF THE STEEL CONVERTER AND THE CUPOLA, WHICH FACILITATES THE TRANSPORTATION OF THE IRON TO THE BLOWING VESSEL

it difficult to hold the metal with the stopper, and this method of pouring is hazardous, unless the metal is under absolute control. In only a few shops in this country is converter steel successfully bottom-poured, and the secret of this practice is carefully guarded. It was concluded that, regardless of expense, this method would be pursued, and after many trials all difficulties were overcome and converter steel, for even the smallest castings, is now poured in this way. The bottom-pour ladles, shown at the right, Fig. 2, are of the usual type, equipped with graphite stoppers, which fit into fire brick nozzles. When pouring, a thick layer of slag forms on top of the steel, thus protecting it from the air and preventing it from cooling while pouring the molds. Alloy additions are made in the ladle, but when the amount is too great to insure a proper mixture in this way, a portion of the alloy is added to the metal in the converter.

The plant of the West Steel Casting Co. is located at East Seventieth street and the Lake Shore & Michigan Southern railroad tracks. The main building is 75 x 125 feet, and a large extension is to be made to provide for additional cleaning and molding facilities. A general view of one section of the plant is shown in Fig. 1. The melting equipment consists of one 6,000-pound converter of the Fisher type, Fig. 2, and two 8-pot crucible funaces, shown in the background, Fig. 4. The metal for the converter is melted in a cupola, lined to 36 inches, installed by the Whiting Foundry Equipment Co., Harvey, Ill. Although it is the practice in many shops to use two converters, operated alternately to provide time for repairs and relining, an ample tonnage is obtained from this one vessel to meet the needs of the molding capacity of the shop, and steel is blown every day, regardless of repairs and relining. The converter is lined with high-grade silica brick, and from 25 to 40 heats are obtained from one lining. A ganister lining has been tried, but better results have been obtained with silica brick. The making of repairs and the work of relining is largely done at night. The average blast pressure for blowing the steel is about three pounds and the losses by oxidation, including the cupola melting loss, average from 18 to 20 per cent. The blowing of the steel requires from 20 to 30 minutes. The silicon in the cupola mixtures ranges from 2 to 2.50 per cent and the phosphorus, from 0.03 to 0.04 per cent. While the converter has a capacity of 6,000 pounds, it is lined to produce from 4,500 to 5,000 pounds at each heat. The present shop capacity is sufficient to handle the metal from six blows daily. The foundry is commanded by an electric traveling crane of 10 tons capacity, installed by the Cleveland Crane & Car Co., Cleveland. Although it is customary to have two cranes in converter shops, one to convey the metal from the cupola to the converter, while the other is carrying the ladle for pouring off the steel, a system of rapidly handling the metal has been devised, which obviates the necessity of using another crane. The cupola is operated by a fan, installed by the Buffalo Forge Co., Buffalo, and the blower for the converter was installed by the Piqua Blower Co., Piqua, O. The blowing equipment is located in the engine room, and only short sections of blast piping are required for carrying the blast to the cupola and converter.

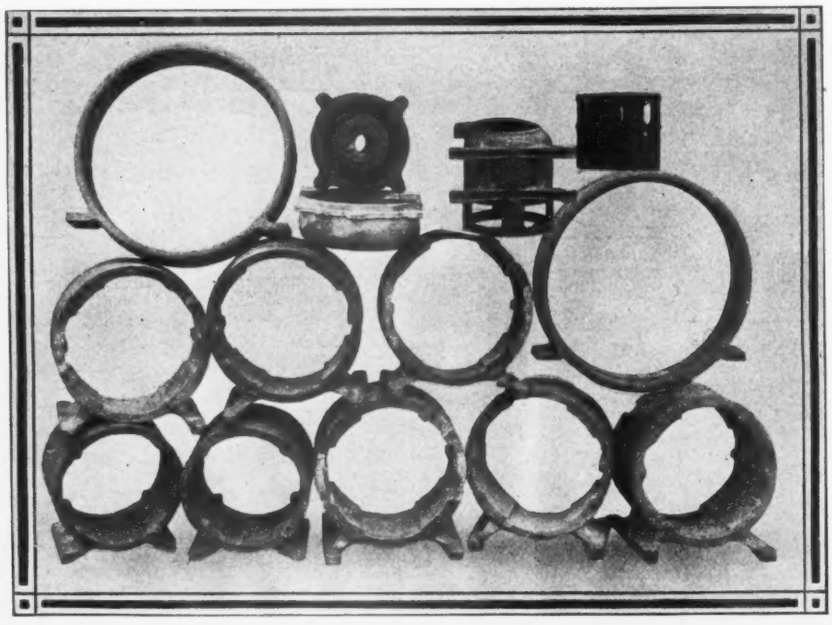


FIG. 3—MISCELLANEOUS ELECTRICAL CASTINGS, MADE FROM CONVERTER STEEL

A large portion of the converter metal is utilized in the production of

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication.

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

FORMULAS FOR THE BRASS FOUNDRYMAN.

Babbitt Metal.

There are several different methods of making babbitt metals. One is to first make an alloy of the most infusible metals and a sufficient amount of tin to bring the melting point within the range of the babbitt kettle. This is termed the "hardening" and is added in the required proportions to the bath of melted tin in the kettle. By another method the more infusible metals are added to the bath of tin in the kettle, directly from the crucible in which they are melted. Still another method is pursued when the alloy is made entirely in the crucible in the absence of a babbitt kettle. In this case the copper is first melted and the antimony is added and is allowed to become thoroughly heated. The crucible is then removed from the furnace and the tin is added, the heat of the hardening metal and what is absorbed by the crucible being sufficient to liquefy the tin. The babbitt is then at a suitable heat for pouring, while if the tin were added to the other metals while in the furnace it might become overheated. Of these different methods, that by which the hardening metals are added in the liquid state is recommended.

A high-grade tin babbitt that will carry heavy loads and will withstand rough usage, being especially suitable for street railway service, is as follows:

	Pounds
Tin	85
Antimony	10
Copper	5

A small amount, as given above, can probably be more easily made in the crucible in which the copper and antimony are melted in the manner just stated. However, when several hundred pounds are made at a time, it is better to first melt the required amount of tin in the kettle and to obtain the correct weight it will probably be found necessary to ingot some of the tin when melted, as the original ingots of tin do not weigh exactly 100 pounds, but vary from 105 to 112 pounds. While the tin is being melted, the copper and antimony are also being melted in the crucible furnace. The copper is charged first and is melted under charcoal. Then the antimony is added in small pieces to avoid chilling the copper, each piece being allowed to melt before another is added. When each addition is melted the alloy is stirred, care being taken to feel to the bottom of the crucible to detect whether the copper has chilled and solidified. If the copper has chilled it will be necessary to superheat the metal until the entire bath is liquid, when the balance of the antimony can be added. When the copper and antimony are melted they can be poured into the bath of tin, which is stirred in the meantime. The liquid babbitt is then covered with a thin layer of powdered soft coal, stirred and cast.

DATA SHEET No. 81, THE FOUNDRY, JANUARY, 1911.

FORMULAS FOR THE BRASS FOUNDRYMAN.

Statuary Bronze.

Many different alloys are known as statuary bronze, some of which incline more to the nature of yellow brass than bronze, as they contain a considerable percentage of zinc. The alloy, however, which seems to possess the greatest claim to be considered standard, is as follows:

	Pounds
Copper	90
Tin	7
Zinc	3

The addition of 8 ounces of lead to every 100 pounds of this alloy is frequently made to facilitate machining.

Another alloy, frequently used on United States government work, is as follows:

	Pounds
Copper	90
Tin	5
Zinc	5

To every 100 pounds, add 8 ounces of lead.

An alloy, which is also considered standard and is frequently used in casting tablets, is as follows:

	Pounds	Ounces
Copper	90	..
Zinc	7	8
Tin	2	8

A tablet alloy which is more expensive, but not so liable to produce smoky castings, follows:

	Pounds	Ounces
Copper	88	..
Tin	6	..
Zinc	3	8
Lead	2	8

For a light colored alloy, the following is sometimes used:

	Pounds.
Copper	79
Zinc	20
Tin	1

As the latter is really a yellow brass, it will be found more suitable for light, thin castings, than for heavier sections, as less difficulty will be experienced with heavy castings if either of the two alloys, first given, are used.

DATA SHEET No. 82, THE FOUNDRY, JANUARY, 1911.

electrical steel castings, Fig. 3, including motor frames, pole pieces, etc. These castings are exceedingly low in carbon, are of high permeability, and an average analysis follows: Carbon, 0.10 per cent; manganese, 0.20 per cent; silicon, 0.10 per cent; sulphur, 0.03 per cent, and phosphorus, 0.04 per cent. It will be noted that this analysis closely approximates that of pure iron. Tests of this steel made at the Case School of Applied Science, Cleveland, shown graphically in Fig. 6, indicate a flux density, in lines per square inch, of nearly 130,000 on 205 ampere turns per inch of length. The magnetization curves of Hadfield steel, annealed soft cast steel, wrought iron, unannealed cast steel, as well as gray cast iron, are also shown. In addition, cast steel car wheels, up to 20 inches in diameter, are also made from converter steel. The use of these wheels, not only for mining but for other industrial purposes, is growing rapidly and for some uses cast steel wheels are replacing the product of the gray iron foundry.

The steel for castings for the jobbing trade is made of another mixture, which analyzes as follows: Carbon, 0.25 per cent; silicon, 0.25 per cent; phosphorus, 0.05 per cent; sulphur, 0.04 per cent, and manganese, 0.70 per cent. Tensile tests of this steel show a strength of 65,000 pounds per square inch and an elongation of 30 per cent in 2 inches. Only low phosphorus pig iron, free from copper, is used for the converter mixture, and the cupola charge consists of 70 per cent pig and 30 per cent scrap. Shop scrap, consisting of gates, feeding heads, etc., is used almost exclusively, but owing to the low casting losses, it is occasionally necessary to purchase outside scrap for the mixtures.

In the crucible steel department, the metal is utilized largely for the production of castings to meet the requirements of the automobile trade, and for small machine tool parts. The section of the shop devoted to this class of work is illustrated in Fig. 4, and the variety of the product is shown in Fig. 5. The two crucible furnaces are rectangular in form, 30 x 60 inches in size. They are a modification of the Milwaukee type, having no bridge wall, and in place of four oil pans for each furnace only two are provided. The fuel oil is conveyed to the furnaces by gravity from an elevated tank in the foundry yard, having a capacity of 150 gallons, sufficient for one day's operations. The oil storage tank is located outside of the building under ground, and has a capacity of 6,500 gallons. From the storage tank, the fuel oil is pumped into the small tank which supplies the furnaces. Each furnace has a capacity of eight pots, but only the four nearest the front, or oil pan end, are within the melting zone, and each heat only consists of four pots. After the four crucibles in the front of the furnace have been lifted out, the four in the back, whose charges have been partially melted, are brought forward, and are ready for pouring in from one and one-half to two hours. The vacancies caused by the removal of the pots are filled by four freshly charged pots, the contents of which have been warmed, but not preheated, by being placed at the end of the fur-

FIG. 4—THE CRUCIBLE STEEL CASTING DEPARTMENT, SHOWING THE FURNACES IN THE BACKGROUND

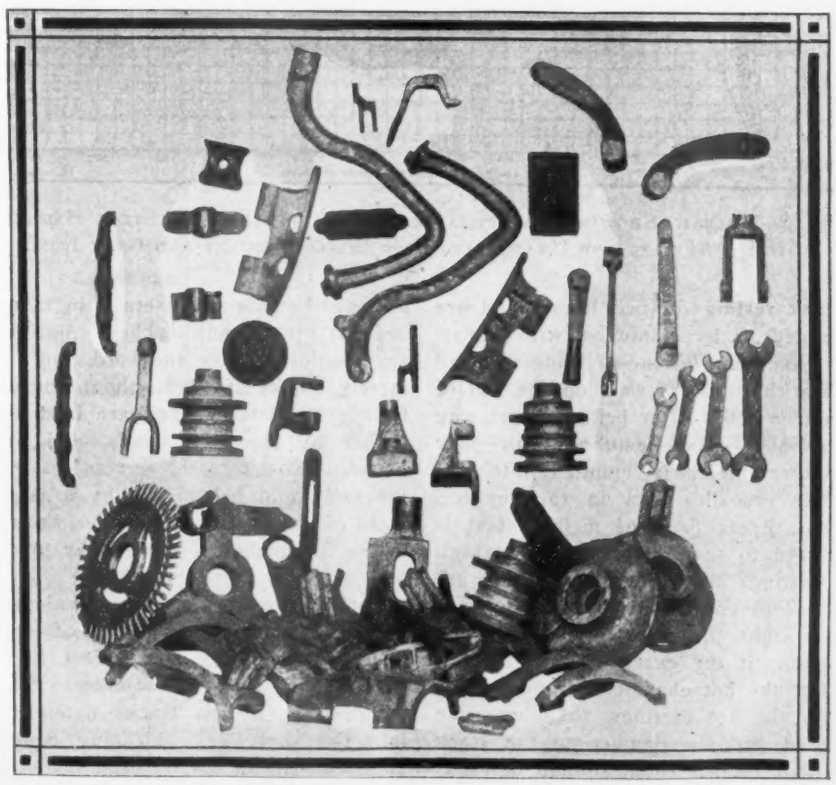


FIG. 5—MISCELLANEOUS CASTINGS, MADE FROM CRUCIBLE STEEL

nace near the stack. The two furnaces have a capacity of 48 pots per day. The fires are lighted at 4 or 5 o'clock in the morning and the first heat is ready at 8 o'clock. The crucibles average about three heats each, although the life of some is prolonged by coating them on the outside with a mixture of ground crucibles wet with molasses water. The coating is approximately ¼ inch thick and is thoroughly dried by placing the pots in the furnace at the end of the day's work. It has been found that the cost of melting crucible steel is approximately 2 cents more per pound than by the converter process and 2½ cents more than in the open-hearth. When pouring-off, the crucibles are set in a shank resting on two horses and are slagged-off by skimming with a flat-end skimmer, instead of being swabbed off with a ball of slag, on the end of an iron rod. After being poured, any remaining steel, insufficient to pour another mold, is emptied into the other crucibles still in the furnace. Thus, every drop of melted steel is utilized to the fullest possible extent.

Castings that require annealing are placed in one of the crucible furnaces over night, the absence of bridge walls making it an excellent soaking pit. After the hot chamber has been filled with the hot castings, the bungs are closed and the damper to the stack is shut off. A small amount of oil is burned in one pan, the amount being gaged by the thickness of the castings to be annealed. The following morning the castings are removed by the watchman and the furnace prepared for the day's run. The annealed castings, when removed, have cooled down to their normal color.

The entire sand pile consists of silica sand, but a facing is used immediately next to the patterns. The molds are coated with a silica wash and are then dried in the ovens. A large amount of snap flask work is made, each mold being banded with hoop iron, as shown in Fig. 4. Many of these snap flasks are poured upright, as illustrated in the foreground, Fig. 4, in which case the bands have to be spread apart at one end to permit the pouring gate and risers to be taken out at the joint. These upright snap molds are dry and hard, and are merely blocks of sand wthout bottom boards or plates. They are held together by the iron bands, and are placed as close to each other as possible, the end mold being held by a large mold of the horizontal type, as shown in the foreground, Fig. 4, or by propping up with iron weights.

For drying the molds, two large, coke-fired ovens are provided, 9 feet wide, 22 feet long and 9 feet high, which open into the foundry. The buggies operate on tracks extending into the shop. The cleaning equipment consists of a sand blast installed by J. M. Betton, 178 Washington street, New York City, Cape May sand being used. For cutting off gates and heads, three cold cutting-off saws have been installed, one 38-inch of the Newton type and two 22-inch, Espen-Lucas. For grinding castings there are three stationary stands carrying 30 x 3-inch wheels, and one swinging arm grinder provided with a 15 x 3-inch wheel.

The power plant is located in a wing to the main building and contains three gas engines, two of 50 horsepower capacity, and one of 75 horsepower capacity, a 45-kilowatt General Electric generator, air compressors, fan, blower, pumps, etc. The electric welding outfit, installed by the Lincoln Electric Co., Cleveland, has proved useful for repairing minor defects in castings and occasionally parts omitted from the patterns are welded onto the castings, which, otherwise, would have to be rejected.

The cost of erecting and equipping a plant for the manufacture of light steel castings has been variously estimated, and it has been stated by some authorities that a converter shop could be built and equipped at a cost of $15,000. While this foundry, in addition to the converter, contains a crucible steel casting department which necessarily increased the cost, yet, notwithstanding conservative estimates to the contrary, the outlay for the site, buildings and equipment approximates $70,000.

The officers of the company are as follows: R. H. West, president; E. W. Pike, vice president and superintendent, and D. P. Lansdowne, secretary.

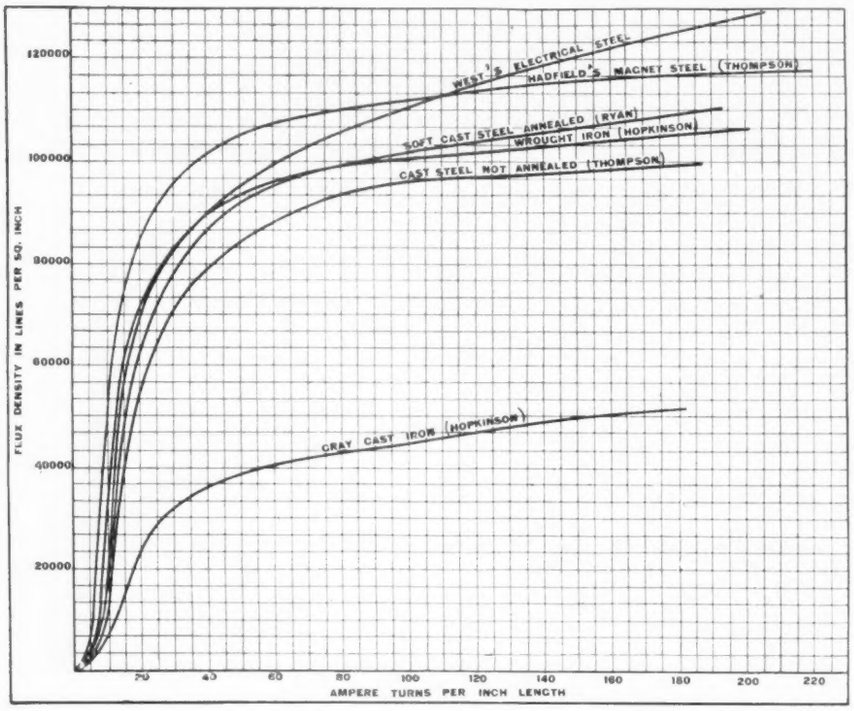


FIG. 6—DIAGRAM, SHOWING MAGNETIZATION CURVES OF ELECTRICAL STEEL, HADFIELD STEEL, ANNEALED AND UNANNEALED CAST STEEL, WROUGHT AND GRAY IRON

Clarus Metal

One of the latest additions to the list of the light alloys is Clarus metal. It is said to be at least 60 per cent stronger than aluminum and one-third the weight of brass. It is claimed that it will take a polish equal to silver, that it does not tarnish, and is sufficiently ductile to be bent cold when cast.

The alloy consists largely of aluminum and can be produced at reasonable cost. It is recommended for automobile, aeroplane, railroad and other castings. This material can be spun and stamped, rolled into sheets and drawn into wire, tubes and rods. Tests of wire and tubing are given in comparison with aluminum wire and tubing which show the superiority of Clarus metal in these forms; but tests of sand castings have not been made, although these would be of more interest to the founder and would furnish a better idea of the probable value of this alloy.

PATTERN CONSTRUCTION ELEMENTS--VI

A comprehensive discussion of skeleton patterns, swept-up molds and strickles for the apprentice and journeyman patternmaker

By Joseph Horner

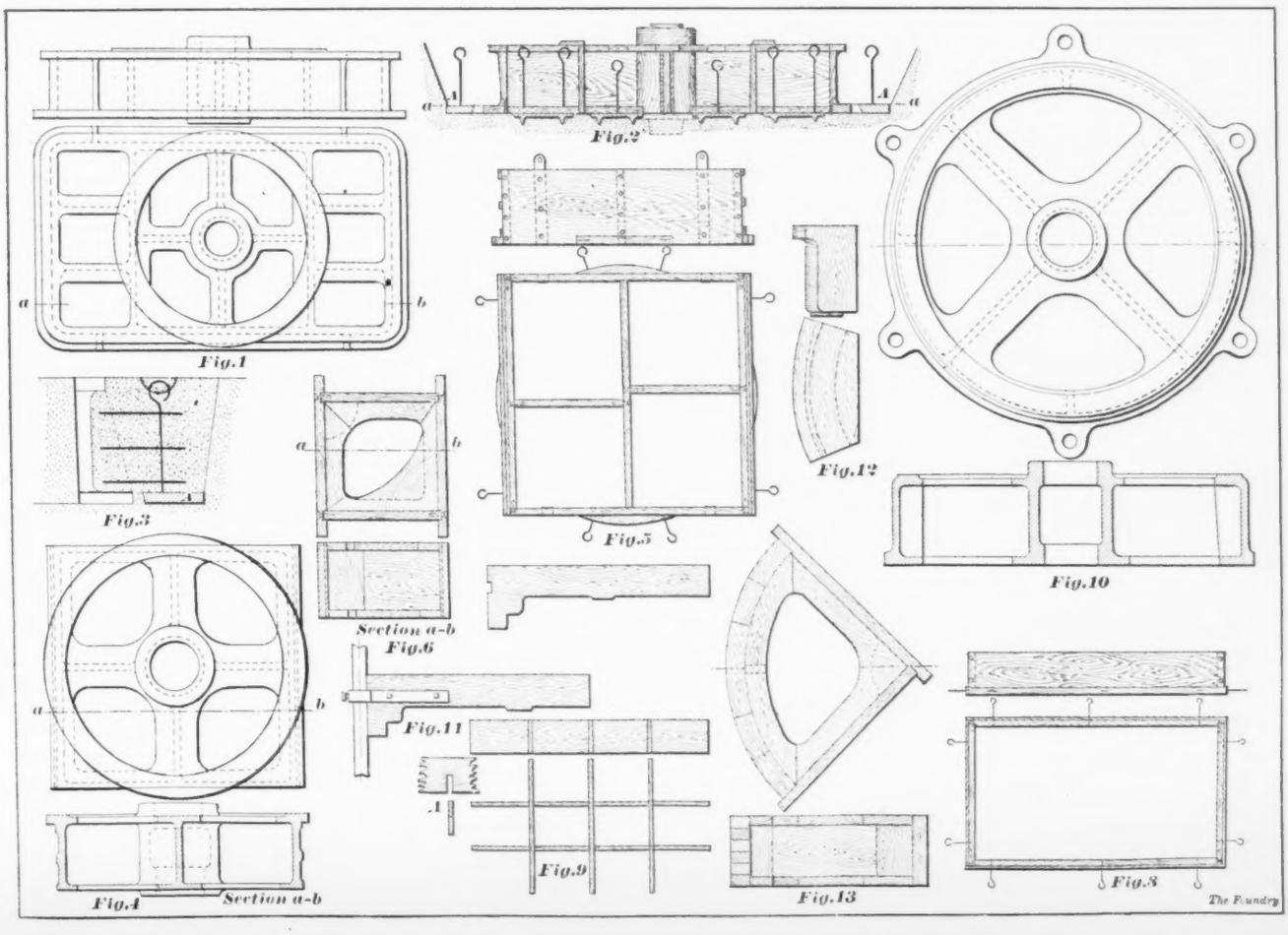
THE patternmaker and molder are ever a pair of schemers. The range, not only of possible, but of practicable methods is very wide. The work provides more scope, I think, for the choice of different ways of arriving at the same desired end than does that of the machinist, the boilermaker, or the blacksmith. The problems which arise in connection with the production of castings, are numerous, varied, and often antagonistic.

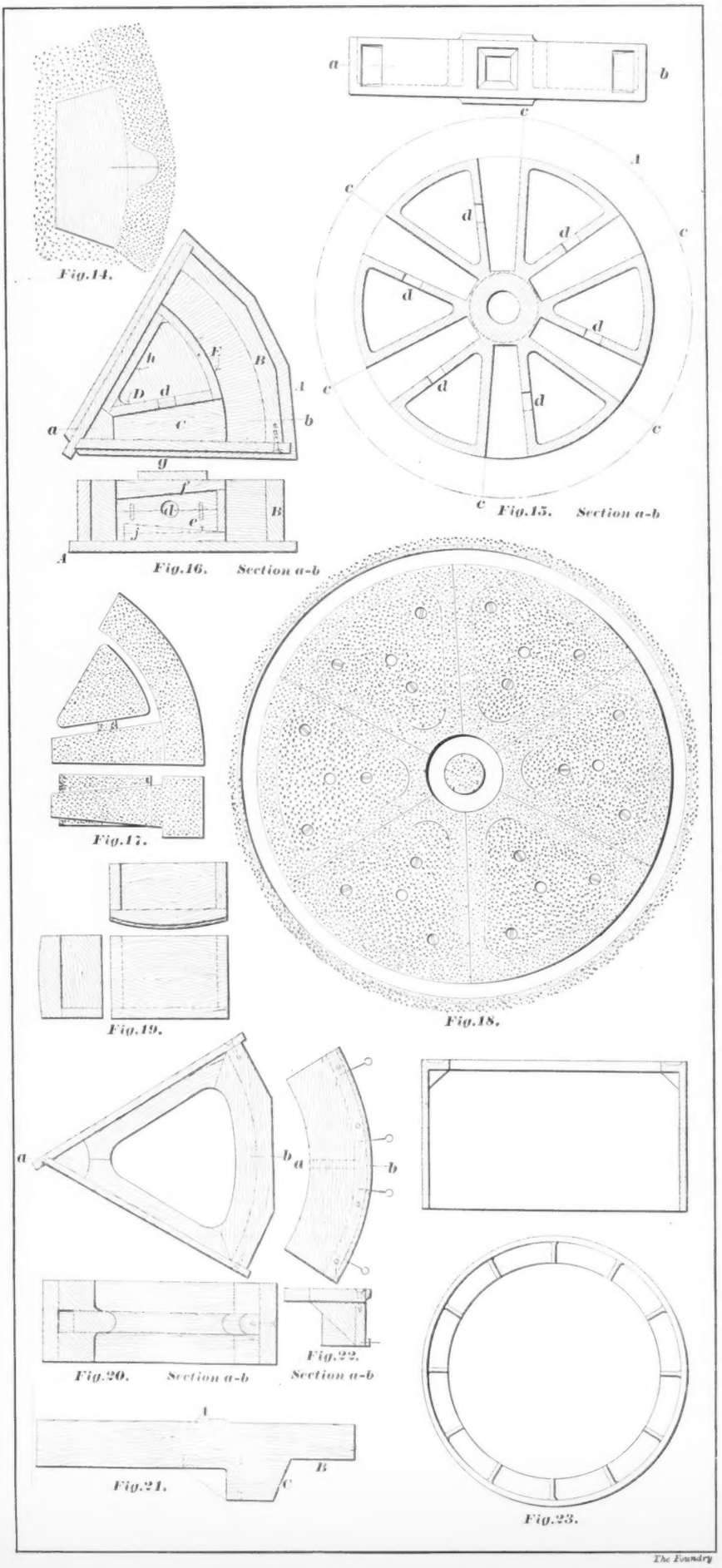
In this article we will consider a class of work which is more or less of a jobbing character, where the cost of a complete pattern cannot be justified when the expense of a pattern would, in some cases, be greater than the value of the one casting, or the few castings required, and when the castings might never have to be repeated. Here the opportunities for the scheming out of short cuts and time and lumber economies are extensive. This is the class of work on which skeleton framings, segmental blocks, swept-up and strickled molds, predominates. There is, sometimes, so little apparent relation between the pattern parts and the mold, that the patternmaker has to spend considerable time with the molder, marking out and measuring. This is a class of work which is sometimes abused by the foreman patternmaker, who, in order to keep down the costs of his own department, entails extra expense, which is not legitimate, upon the molder. It frequently happens that a mold for a small job is swept-up, or is made to mold from a swept-up pattern, when a wooden pattern might be cheaper on the whole.

In the following examples, it is not necessary, nor would space permit, to give full details and descriptions of the work involved, such as would be suitable for descriptions of individual jobs.

Large Plates.

Bed plates, base plates and center frames for cranes of many kinds, afford wide scope for economies on the part of the patternmaker and molder. They vary in outlines, being square, oblong, and circular. Large frames are made from complete patterns only when the work is standardized. A large number of special and unusual castings are required in this kind of work. While complete patterns, to deliver themselves without cores, divide favor with cored work for standard use, for occasional, and sometimes too for rather frequent service, skeleton patterns alone, with cores, are adopted. These patterns have no further resemblance to the casting than is embodied in their external, rectangular outlines. When standard





castings have no bottom flanges they are generally made for self-delivery. If they have such flanges, it is generally better to core out all the interior, even in the case of standard patterns, than to lift heavy masses of green sand over the bottom flanges, which is the alternative. All these methods are familiar in crane shops.

A bed without bottom flanges which delivers itself, need not be shown. The first examples are those of rectangular beds, and both are flanged on the bottom, which is, of course, the best practice, the bottom flange fulfilling the function of resisting the great tensile strains to which such beds are subject.

Crane Bed.

From a study of the elevation and plan of the rectangular crane bed, Fig. 1, it can readily be seen that a complete pattern of this casting, to deliver itself, must have the bottom flanges, within and without, loose, and when the flanges encircle the bed, as in this case, they must be preferably framed together to form one rectangular piece, Fig. 2, which is a longitudinal section through the pattern in the plane *a b*, Fig. 1. If made as separate strips, the flanges could not be drawn backward on account of their width, and on account of the limited space into which to withdraw them. Furthermore, the overhanging mold could not be mended where it became broken down by the withdrawal of the flanges, as would certainly happen. In this case the wider flange is molded in the bottom, as in Fig. 2, to insure sound metal where it is in severe tension, and the amount of overhang of the sand is considerable, both on the outer and inner flanges. Hence, a plane pattern joint must be made along the top face, *a a*, of the rectangular flange framing, Fig. 2, which is lifted away after the removal of the main pattern, and of the green sand cores carried on the plate grids, shown in relation to the pattern in this illustration.

Use of Drawbacks.

A drawback is often used to avoid pulling a single, wide flange inwardly from underneath overhanging sand, because it is difficult to patch in such cases, while the sand on a drawback can be readily repaired and replaced. The mass of sand encircling a frame, similar to Fig. 1, having wide bottom flanges, can be carried on a single, iron frame plate, *A*, Fig. 2, encircling the flange, and provided with eyes for lifting it. Rodding is necessary to support the sand which overhangs. The bottom flange, being left loose,

the main pattern is first withdrawn, then the ring of sand is lifted, and lastly the loose flange. An enlarged section through the outer sand and plate is illustrated in Fig. 3.

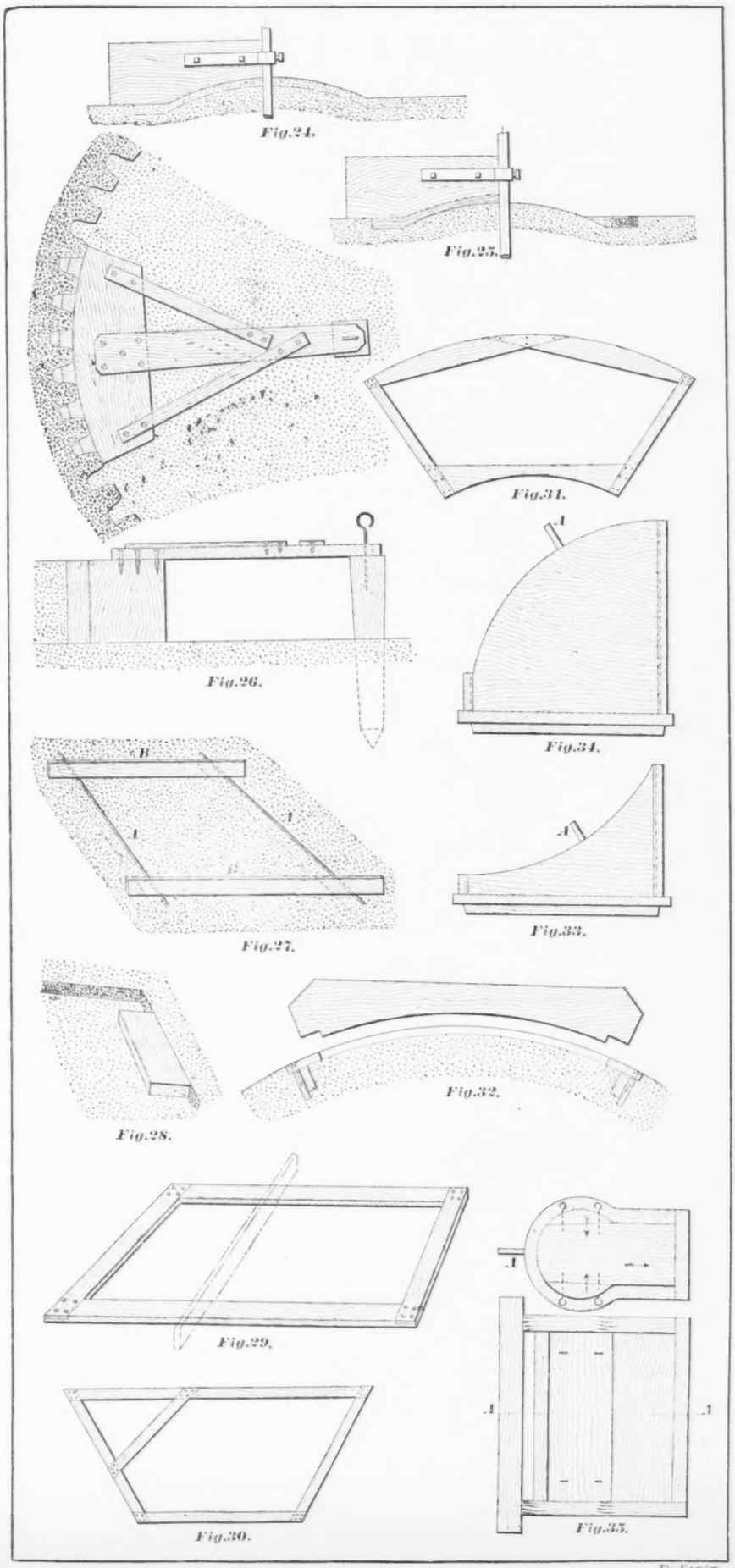
The green sand cores which occupy the central portion of the frame, involve nearly as much work as if prepared in core sand in separate boxes, and the latter are much less liable to suffer injury. This, notwithstanding, is an example where, on the whole, self-delivery and green sand cores seem preferable, because the castings were standardized and are repeated, year after year. The cores, too, are numerous, and the metal rather light, which is in favor of green sand and self-delivery. The next example, Fig. 4, is that of a different model. It is a square center to fit within a steel-plated truck, in place of a complete cast truck bed, Fig. 1. In this, the cost of a skeleton pattern, Fig. 5, one core box, Fig. 6, and a sweeping board, Fig. 7, for a bed, is considerably less than that of a complete pattern, so that even for standard work, in this case, a frame pattern and coring are better than a complete pattern for self-delivery.

Skeleton Pattern.

The skeleton pattern illustrated in Fig. 5 is made entirely open, that is, as a frame without top or bottom. Sides and ends are rebated together at the corners, and are prevented from becoming rammed inwards about the center by the insertion of internal cross bars. The planing strips are similar to those shown in Fig. 4, except those on top, which are skewered on. Those portions of the facing for the slewing gear, which project beyond the sides, are also skewered on. Alternatively screws may be inserted in these pieces instead of skewers and removed before the ramming is completed. There is no pattern boss which is swept by the board, Fig. 7, and nothing suggestive of the form of the interior of the casting.

The Core Box.

The core box, Fig. 6, comprises a rectangular framing, enclosing a segmental boss, Fig. 4. Within this framing, top and bottom pieces are laid in position as shown, to form the flat ribs, or webs, of the casting, and are suitably jointed. The main frame being secured with screws, and the ribs being loosely fitted, the removal of the screws, after the core is made, permits the ready removal of the sides of the box piecemeal from the core, and to permit this, the ribs are jointed in the manner shown. It is well to make these large core boxes



a trifle smaller than the actual dimensions measured from the drawing. The reason is that the ramming of large cores slightly strains the box sides outwards, which, when the sides are removed, leaves an enlarged core; 1/16 inch below size on each face is a suitable allowance.

Method of Molding.

In molding this casting, the board, Fig. 7, sweeps a bed in which are the recesses that coincide with the central boss and its core print, and the facing which has to carry the geared slewing ring, Fig. 4. On this bed the skeleton pattern is laid, and is rammed around its outside edges only. A plain top is rammed separately on a hard and levelled bed of sand, or on a cast iron plate. If any facing pieces are required, as is sometimes the case, they are set by measurement. The cores are rammed and dried, tried in the mold, thicknesses measured, and fillets rubbed off before they are blackened. Such a pattern as this can be altered readily at the rebated ends. It can be shortened or lengthened, the first involving cutting off, or stopping off, the second the insertion of suitable supplementary pieces. Since these patterns occupy a considerable amount of space in the pattern storage, this facility of alteration is a matter of considerable value.

Another Method.

A method better suited for standard work, is to make a pattern complete, and like the casting, except in so far as coring out is concerned. Sides and ends are rebated together as in Fig. 5, but the top and bottom are both covered with boards, open-jointed, and rebated into the edges of the sides and ends. The circular ring facing and boss are made complete and the top part of the mold is rammed in place upon the top of the pattern. The board, shown in Fig. 7, is still used to strike a bed, upon which the pattern is laid, the ring facing and bottom boss lying in the corresponding impressions swept up by the board.

When a pattern is made solid-plated there is an additional secondary advantage. The shapes of the ribs and webs can be marked out on the top face with deeply scribed lines, and the core boxes made thereto. When bringing the pattern and boxes from storage for further use, these outlines remain a safe reference by which to check the boxes before sending them into the foundry again. In case of alterations also, such a full-sized drawing remains of value for reference. In the foundry, too, the molder can see, on reference to the pattern, what thicknesses of metal he ought to have everywhere, without sending for the patternmaker and his drawing.

Rectangular Molds.

There are many large rectangular molds of which this is broadly typical. Machinists' surface plates and floor plates, boilermakers' levelling and bending blocks, blacksmiths' upsetting blocks and similar articles seldom have complete patterns made. An open frame, Fig. 8, of the length, width and depth required, is made, and the outside sand is rammed against this when laid on a levelled bed, over a cinder bed for venting the large flat area.

If a plate like this is not stiffened with cross ribs in the casting, rough cross ribs may be fitted in as in Fig. 5; but when ribs are required, as they are in large frames, these are made as pattern parts, Fig. 9, being halved through the center *A*, to go within the outer frame, Fig. 8, and to be rammed in a top box. In that case sand must be filled into the bottom of the mold—parting sand or sheets of paper intervening—and must be strickled off to the thickness of the plated portion of the plate or block. On this strickled surface, the ribs and frame will be laid for ramming, a joint being made with parting sand or paper. The outer frame is of the same thickness as the casting when the ribs, Fig. 9, are not made by coring out, which is not necessary. The top box being laid on, the ribs and thickness of the sides are obtained by ramming the spaces within the frame laid on the strickled face. After the removal of the top, the bottom sand, which occupied the thickness of the plate, is taken out carefully, leaving the bottom face of the mold protected with paper, again open. If holes are required in the plate, the cores are set in print impressions located by measurement or by template.

Cored Molds.

Molds are frequently made to which the parts provided by the patternmaker bear little resemblance. They are not even skeletons. Such molds are chiefly constructed with cores, with or without the assistance of sweeps and segmental blocks. In some cases cores are laid to a circle and abut against each other. Large gear wheels are sometimes made in this way, the teeth in one set of cores, the arms in another. In other cases, a segmental block is worked round to form a circular wall of sand within which the mold is enclosed. The circle for setting the block may be simply marked on a leveled bed of sand, or a sloping wall of sand may be swept, the lowest edge of which is the circle to which the block is laid for ramming. Bosses, facings, etc., are sometimes swept by the board, or they are set by measurement, both in top and bottom.

Circular Bed.

A circular bed, Fig. 10, if made to deliver its interior, would be open to the same objections urged against making a rectangular bed in the same manner. Of the two, a circular bed is the simpler job to make with a few pattern parts, because only a board, Fig. 11, a block, Fig. 12, one core box, Fig. 13, and one lug are required. The bed is molded upside down. The board, Fig. 11, sweeps the bed on which the block, Fig. 12, is laid and worked round, the outside sand being rammed against it in short sections. Lugs are rammed at intervals from the pattern lug, Fig. 14, laid against the block. Four cores are made from the box, Fig. 13, and set by measurement, and a central core is swept up and set by its print impression. A plain top only is required, which is rammed separately.

Capstan Head Casting.

The casting, Fig. 15, which is the head of a capstan, into the tapered recesses of which the bars, or levers, are inserted, is made by cores only, no single pattern part, except the central bosses which are measured in, in the top and bottom, being used. The circle, shown dotted at *A*, is struck on a level bed of sand, and six cores abutting at *c c* are laid down by that line, and in contact with each other. Each core includes one tapered hole for a capstan lever, and the lightening recess adjacent, a hole, *d*, connecting the two, through which a core iron passes.

Core Box and Core.

The core box is outlined in Fig. 16, and one core in Fig. 17. The box is laid on a bottom board, *A*. Two sides, set at the correct angle taken from the plan, Fig. 15, are enclosed by a quadrant piece, *B*, the inner edge of which is cut to the curve of *A*, Fig. 15. The recess, *C*, for the lever is formed by the outside piece of the main box frame adjacent, and by a strip, *D*, opposite, the thickness of which corresponds with the thickness of metal between the recess and the lightening opening, Fig. 15. It is made in two pieces, dowelled, the opening, *d*, Figs. 15 and 16, being cut in the joint face. The taper below

and above is imparted by one piece, *e*, nailed on the bottom board, and *f* attached to a batten. The sweep, *E*, corresponds in thickness with the thickness of metal in the rim of the casting, and together with the piece, *D*, and another *h*, encloses the lightening hole. In the bottom of this hole the piece, *j*, is fitted to give the thickness of metal at this point. The casting is open on the other face.

Fly Wheel Mold Without a Pattern.

The method of making a fly wheel mold without a pattern is shown in Figs. 18, 19 and 20. The shape of the casting is obvious from the uncovered molds, Fig. 18. Only two pattern parts are required, a ramming block, Fig. 19, and a core box, Fig. 20. To make the mold, a level bed is first struck. This can be done by working one edge of a plain, parallel board around a center, laying a level on the top edge of the board to insure striking a level bed. A bed can also be levelled with two straight edges laid horizontally in the sand bed of the floor, the strickle working over their top edges. On this bed a circle is struck as a guide for setting the block, Fig. 19. This is loaded with a weight, and sand is rammed against its curved face and for a foot or more outside, sufficient to withstand the pressure of metal; or it may be rammed within any suitable cheek flask to confine the sand. The segmental block is shifted around until the circle of sand is completed. Six cores are made in the box, Fig. 20, dried, and laid in their places in the mold, abutting against each other, while the thickness of the rim space is checked with a strip of wood. A center core is put in, Fig. 18 showing the open mold at this stage. A plain top is laid on and with the pouring basin completes the mold.

Brake Ring.

Figs. 21 and 22 show the parts required for a brake ring for a steam hoist, swept up without a pattern. It is very desirable, though not absolutely necessary, to prepare a bed with a sweeping board, Fig. 21, because that affords a valuable guide to the molder in working the segmental block around. In any case a top mold has to be prepared, for which sweeping up would be necessary. The method suggested follows:

The sweep, Fig. 21, is cut on both edges for top and bottom, respectively. In this case the edge, *A*, is not used to sweep the actual mold, but for a dummy upon which the cope is rammed. After the cope has been rammed, the lower sand, that which formed the dummy mold, is dug out, and the board is rolled over and fastened to its bar with the joint edge, *B*, resting on the joint face, on which the cope was rammed. Then the interior is swept, imparting the back of the ring, its bottom edge, and a space with a sloping edge at *C*, which space is filled and rammed with sand against the face of the ring, giving the working edge.

The ring segment, Fig. 22, has the shallow flanges fastened to it between which the brake strap works, the lower flange is wired on. The bracket at the back may be fastened as shown, or may be left loosely. The positions of these brackets, six or more, are measured in the mold. The segmental pattern may be built-up with segments, or may be cut from a solid piece of material, the first method being preferable. The saving in cost is that of an entire ring, against which has to be set off the cost of the segment and sweeping board, and some little extra time on the part of the molder in working the sweep. Using a pattern, the top and bottom boxes would still have to be rammed. If one-half dozen such rings were required a full pattern would be cheaper. For a breakdown job the sweep is quicker and cheaper.

Limitations to Sweeping in Green Sand.

There are various limitations to the adoption of sweeps in green sand. These are depth, mass, overhanging parts and sharp corners, in which cases sweeping in loam is preferable; or alternatively, when practicable, constructing partially in cores, and partly in green sand, or in dry sand. Loam is more costly than either, because of the bricking up, the plates, joints, careful drying, and finishing and blackening required.

Take the case of the foundation ring, Fig. 23, which might measure from 4 to 6 feet in diameter. If a large number of rings were ordered, an iron pattern is to be preferred, while a wood pattern is out of the question. For a few castings, sweeping up in loam is the proper method. Green sand sweeping would offer great difficulties on account of the great depth, and the large bodies of sand. Sweeping, such as is done in plastic loam, could not be done in green sand, as the sand would fall down, and this also applies to dry sand. The sand would have to be rammed against sweeps as in Figs. 18, 19 and 22, which is out of the question here. Hence, the interior and exterior must be bricked-up and swept-over with loam, the details of which do not concern us in this connection.

The cases where green sand sweeping show to best advantage are those of shallow molds of large diameter. Loam work is uncalled for here, and its extra cost has no corresponding advantage.

A difference between the formation of tops swept in loam and in green sand is, that the first is almost invariably swept directly, and the second is invariably rammed on a dummy mold, as for Fig. 21. Hence, in green sand sweeping, a dummy mold for the top is swept first, and the top is rammed on this, located by stakes if the mold is in the floor, or by the box pins if contained wholly in flasks. Then the dummy sand is removed, and the lower part of the mold is swept.

Green Sand Sweeping.

The dished end, Figs. 24 and 25, is an ideal example of green sand sweeping. A pattern of from 3 to 4 feet in diameter would entail large segmental work. For sweeping, the boards cost but a trifle, and the molder's work occupies scarcely any longer than molding from a pattern. The two boards, one for the dummy cope, Fig. 24, and one for the bottom of the mold, Fig. 25, require little explanation. In Fig. 24 is first swept a dummy on which the cope is rammed. The sectional shape of the casting is indicated on the board in Fig. 25, and in the dummy top, Fig. 24.

Fig. 26 illustrates how a gear can be made in green sand by means of a segmental block. If the withdrawal is done carefully the teeth are no more liable to fracture than when withdrawing a complete pattern. The arms are ordinarily made of cores, or a single pattern arm when of T shape. This method of using a segment on a radius bar is very old, but still very useful for a breakdown job at short notice, when a gear wheel molding machine is not available. An alternative method provides for making the teeth of cores.

Use of the Strickle.

The strickle is employed for many useful purposes besides those already mentioned, and always in order to economize material or time, or both. If its edge is plain it strikes a plane or level bed. It is used thus by drawing it along under the guidance of straight edges, leveled in the foundry floor. These straight edges, *A A*, Fig. 27, are bedded into the sand, and

are first approximately leveled with a spirit level. They are then corrected by means of two other parallel straight edges, *B B*, laid across *A A*, which serve as winding strips, the molder kneeling and sighting along their top edges, and beating down the high corners with a mallet. Then the sand is strickled off level with the top edges of *A A*. These straight edges are made in various lengths and are usually wood. They are also made in wrought iron with edges planed. Such levelled beds may form the bottom of an open mold, or of one covered with a top only. On the bed thus strickled, mold outlines are marked as in previous examples, as well as centers, when required. On these beds the patternmaker and molder conjointly construct molds with only a strip, Fig. 28, or a few strips, blocks, or individual pattern parts. Foundry plates and rings for loam work, back plates for flasks, core plates, etc., are made in this way. A leveled bed rammed sufficiently hard, is used as a dummy on which to ram cope parts of molds, when there is no corresponding pattern face available.

Sometimes a level bed is swept by the edge of a board rotated by one of the sweeping bars, similar to Fig. 11. The advantage of this method is that central bosses and prints can be swept simultaneously, and circles for setting parts by can be marked with a vent wire from a line marked on the board. This method is used in many kinds of work, Fig. 18, circular or otherwise, and in machine-molded gears.

Bed for Light Patterns.

Another of the utilities of a level strickled bed is that it affords a level surface on which to lay a flat, flimsy pattern. The bed, by affording support to the pattern, prevents risk of its becoming rammed out of truth, and fulfills, in fact, the function of a bottom board. If such a pattern has projections on its lower face—bosses, prints, brackets, flanges, lugs, etc.—recesses are dug out with the trowel to receive these after the bed has been leveled. This is done not only in molds covered with a top, but in molds included wholly in flasks.

When a strickle is controlled by the edges of a skeleton pattern, Fig. 29, it is done to save timber chiefly, with the time entailed in fitting it. Any frame, of large dimensions, for work which is not well standardized is usually thus made, with the further advantage that in many cases ramming can be done more thoroughly. The broad area being left open, it is rammed, vented, and strickled more effectually than if the pattern were boarded over.

In many standard patterns, where a solid plating of timber is used to ram on instead of hard sand, the encircling frame is still employed, but the timber center is laid in loosely in narrow strips, to be removed during the ramming of the sand face. This, of course, applies to bedded-in patterns. When patterns are turned over, the face, which is to be in the bottom, is rammed before turning over.

The footplates used in crane work, and over pump wells, on platforms, and in boiler houses are frequently made from skeleton patterns of wood which give the outlines only. The checkering is made in the mold by stamping, a number of checkers being nailed on a strip of wood of convenient size to handle. Such patterns are frequently pierced with holes instead of checkers, and in this case core prints are stamped in. Each of these operations is slow and would not be adopted in standard footplates, for which metal patterns are prepared at considerable expense, or rolled steel plates with ribs are preferred. The illustrations, Figs. 30 and 31, show the construction of skeletons suitable for patterns of irregular form. Strips are halved together, straight or curved, as required. A pattern that would "work" at the corners must have a diagonal strip, Fig. 30. Templates are similarly made by the patternmaker only that they are not half lapped at the corners, but only secured with small battens.

The employment of a simple strickle may save much money every week in almost any shop. It avoids large areas of timber, perhaps the least of its economies. In curved work it yields even greater economies, including curved portions both of patterns and core boxes. To fit these solidly, cuts into much timber and occupies considerable time. Compare, for example, the time required in making a curved tank, or lighthouse plate solidly, and that required for strickling, Fig. 32. In many other cases of which this is typical, large areas of patterns, which are curved, are left unoccupied with wood, and are strickled. Extensive curved portions of cored work are not always made by fitting blocks of wood cut to the curves, but the edges of the box are cut correspondingly, and the sand is strickled. Figs. 33 and 34 show plain boxes with concave and convex strickled edge, *A*. Fig. 35 is the jacket core box for a small cylinder showing the strickle laid against the outer edges. The strickle has a still wider sphere. In addition to the foregoing examples, the strickle in the form of sweeping boards, is employed in loam patterns, and in sweeping cores of various shapes.

A Chilling Mixture

By N. W. Shed

Question:—We would like to know what mixture of iron is generally used for grinding burrs used for small grinding machines. We would like to know whether we could add ferro-manganese in the ladle and obtain the desired hardness in a melt of gray iron of ordinary analysis. The castings are approximately 6 inches in diameter and ⅜ inch in thickness.

Answer:—The iron used for grinding machines is usually low in silicon, similar to that used for car wheels. It generally runs high in sulphur, above 0.12 per cent. The silicon varies from 0.40 to 0.80 per cent. White iron used to make malleable castings is frequently used for grinding burrs, which is usually low in sulphur and manganese. If it is your desire to cast these burrs against a chill, leaving one side soft, the silicon should be increased over a range from 1.10 to 1.30 per cent, according to the sulphur and the depth of chill required. The addition of ferro-manganese to a ladle of soft iron would not make the metal sufficiently hard. The high silicon content, about 2 per cent, would keep the metal soft. A large amount of grinding iron is made with a high manganese content, over 1 per cent, but at the same time the silicon is low. A mixture containing 50 per cent car wheels, 10 per cent steel scrap and 40 per cent hard machinery scrap would make a good chilling iron. If a harder mixture is required, add white iron or more car wheels. No pig iron is required for this class of work. The scrap will increase the sulphur, which is of value on a good grinding surface. The metal will have approximately the following composition: Silicon, 0.75 to 0.90 per cent; sulphur, 0.12 to 0.20 per cent; phosphorus, 0.20 to 0.40 per cent; manganese, 0.40 to 0.60 per cent.

Philadelphia Foremen

At the monthly meeting of the Associated Foundry Foremen of Philadelphia and vicinity, held at the Manufacturers' Club, Tuesday evening, Dec. 13, a committee, consisting of Messrs. Benkert, Butterworth and Alexander, was appointed to revise the by-laws. "Molding Machines vs. Hand Molding" was the subject discussed by two debating teams and the judges will announce their decision at the next meeting.

MALLEABLE ANNEALING EXPERIMENTS

Reports of tests for the purpose of ascertaining the effect upon physical properties of malleables subjected to successive annealing

By S. B. Chadsey

DURING the course of my regular work in a large foundry engaged in the production of malleable cast iron, and the studies incident thereto, the experiments described in this article were carried out for the purpose of ascertaining the effect that would be produced upon the physical properties of the ordinary furnace product by subjecting it to regular annealings, and at the same time to inquire into the changes of a chemical character that would accompany the successive stages of the anneal. It has frequently been found, especially in connection with the casting of light sections, that pieces might be burnt during the course of the regular anneal, and would show a bright, crystalline fracture, attended by a very undesirable condition of brittleness. Whether this state would necessarily follow upon repeated annealings under suitable conditions of packing and temperature, was one of the points under consideration, and the results are submitted in the hope that they may be of interest to those who are engaged in this particular line of manufacture.

Round and Square Test Bars.

For the purpose of the test, a set of round and a set of square bars were poured, and in order to avoid variations in composition, the iron was all drawn at the same time from an ordinary melt of air furnace, white iron. The test pieces consisted of ten square bars, 1 inch section and 8 inches long, and of 20 round bars having a center portion ½ inch in diameter and 8 inches long, while the ends, for gripping in a tensile testing machine, were ⅝ inch in diameter and 3 inches in length. The square bars were ground to free the surfaces from sand and adhering scale and to facilitate the subsequent preparation of samples for chemical analysis. Ten sets were made, each set consisting of one square and two round bars, wired together and tagged for convenience in handling, and all were then subjected to a regular anneal along with ordinary commercial castings in a coal-fired oven. In this, as in subsequent annealings, practically one week elapsed from the beginning of firing to the dumping of the oven.

The Tests.

At the end of the first anneal one set of bars, consisting of one square and two round bars, was taken from the others and the round bars were subjected to a tensile test. After being broken, one part was bent by repeated blows until cracks, appearing at the outer portion of the bend, indicated that the fracture was about to occur. A short piece was cut from a fractured end for the purpose of showing the appearance of the fractured surface, and properly numbered for future reference. At the same time, four samples for analysis were prepared from the square bar in the following manner: The outer surface was first lightly ground, sufficiently to remove the layer of oxide and any adhering scale, and the bar was then placed on a planer and a 1/16 inch cut taken from the surface. This constituted

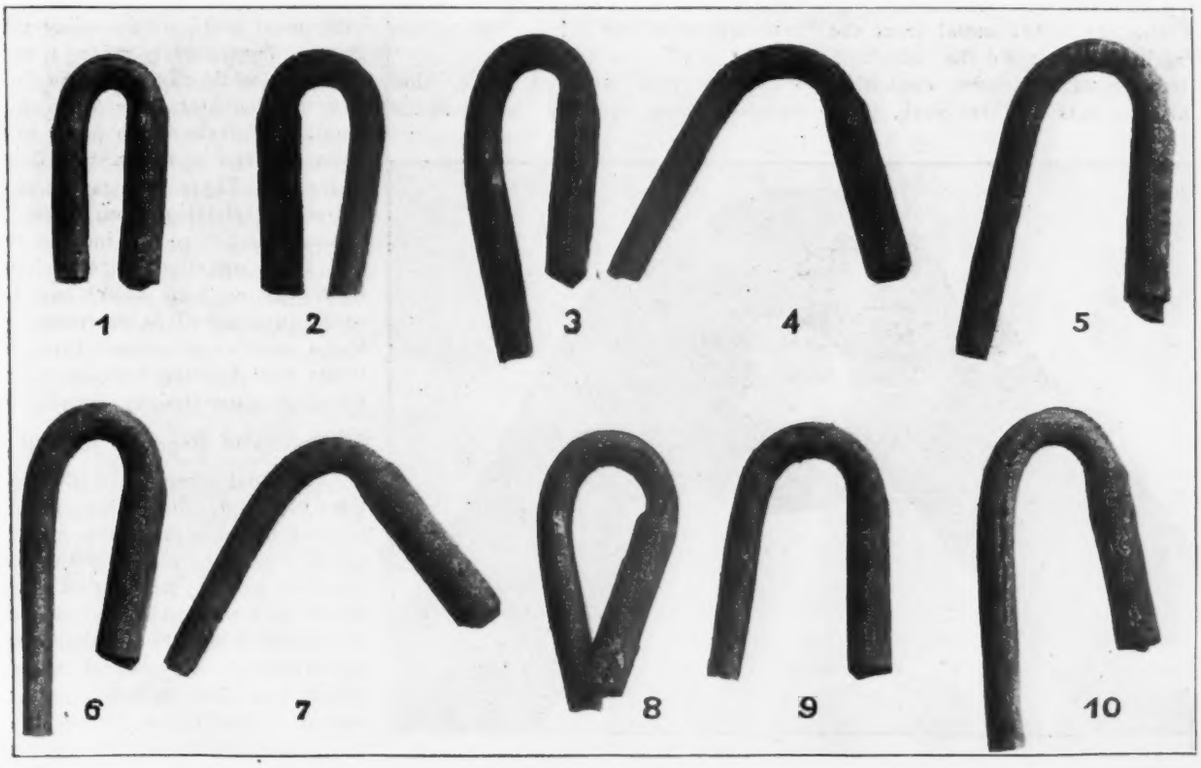


FIG. 1—BENDING TESTS OF BARS FROM EACH ANNEAL FROM NOS. 1 TO 10, INCLUSIVE

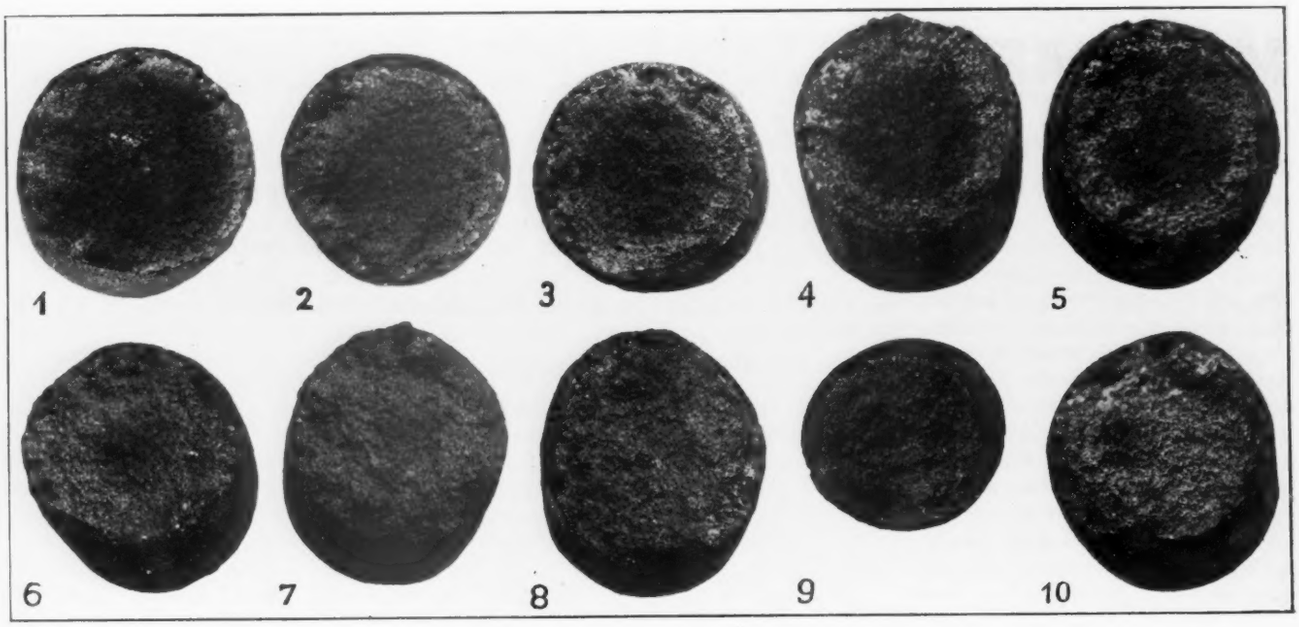


FIG. 2—FRACTURES OF THE TENSILE TEST BARS FROM NOS. 1 TO 10, INCLUSIVE

the first sample. A second cut 1/16 inch deep, was taken for the second sample, and third and fourth cuts were taken in a similar manner for the third and fourth samples. Sample No. 1, therefore, represented the outer layer to a depth of 1/16 inch. Sample No. 2 represented the metal in the layer 1/16 inch deep below the outer 1/16 inch of surface, while samples Nos. 3 and 4 represented successive layers, each 1/16 inch below the former. By making analyses of these samples it was hoped that some knowledge of the changes in the metal from the surface inwardly could be obtained. The balance of the bars, consisting now of nine sets of three each, were returned to the ovens for a second anneal, at the end of which one square and two round bars were used for tests similar to those outlined in the preceding details. The remaining bars were returned for a third anneal and this routine was continued until all of the bars were used. Ten sets of tests are, therefore, recorded upon pieces that had been annealed in the regular way from one to ten times, the last bars having been through ten successive anneals of one week each. Only eight sets of analyses are shown, however, owing to the loss of the square bars from the last two sets.

Turning now to the results that were obtained, it may be observed from the values shown in Table I, that the strengths of the test bars under tension were not uniform, nor were they as high as they should have been. This feature of the cast was due, however, to the fact that the form of the test bar was an unsuitable one and that, in consequence, there was a tendency toward the development of internal shrinkage weakness that lowered the breaking strength in all cases, and in some instances reduced it very considerably. It may be stated, however, that this difficulty was overcome in subsequent work by enlarging the end grips. These were made 1 inch in diameter, while the center portion, ½ inch in diameter, was reduced to a length of 7 inches with fillets of fairly large diameter at the junction with the end grips. These bars gave a strength for similar metal of from 45,000 to 50,000 pounds per square inch in tension and the elongation in 4 inches was frequently as high as 10 and 12 per cent. In many cases, moreover, it was found possible to submit them to extreme cold bending tests, a sample of which is illustrated in Fig. 3.

FIG. 3—MALLEABLE IRON TEST BAR SUBJECTED TO EXTREME BENDING TESTS WITHOUT FRACTURE

Results of Repeated Annealing.

The actual strength of the bars or the variations in value that they showed did not mask the main point which it was the object of the tests to examine, namely, whether or not there would be a marked change in strength and elongation between the bars that had received one anneal and those which had been given repeated annealings. Looking at the results, with this consideration in mind, it will be seen, if it be allowed that the bars that received one anneal only may

both have been marred by excessive shrinkage weaknesses, that no such progressive change was apparent. Those which had been through the annealing ovens ten times gave values that were practically the same as

Table I.

TENSILE STRENGTH AND ELONGATION OF TEST BARS.

Number of anneal.		Tensile strength, pounds per square inch.	Elongation, per cent, in 4 inches.	Approximate angle reached before breaking under bending test, degrees.
1.	A.....	37,690	3.50	180
	B.....	37,230	3.50	90
2.	A.....	35,860	3.50	180
	B.....	41,700	6.00	180
3.	A.....	47,720	9.50	180
	B.....	46,450	8.25	90
4.	A.....	49,000	7.50	110
	B.....	41,870	5.20	90
5.	A.....	37,130	——	180
	B.....	33,820	8.00	180
6.	A.....	43,090	——	180
	B.....	38,800	4.25	180
7.	A.....	41,600	6.75	110
	B.....	32,750	3.50	75
8.	A.....	38,450	4.50	180
	B.....	31,270	3.00	180
9.	A.....	36,950	5.25	180
	B.....	36,430	4.00	135
10.	A.....	41,080	6.25	180
	B.....	36,950	——	135

those obtained from bars that had received fewer treatments.

In Fig. 1 are shown bending tests of bars from each anneal, and it will be observed that No. 10 bent as well as No. 1, and gave evidence throughout of possessing physical properties about the same as those shown after the full transformation of the carbon from the combined to the graphitic or *temper* condition. The ends of the tensile test bars, from No. 1 to No. 10, after fracture, are shown in Fig. 2. After the first anneal the narrow ring of largely decarbonized metal surrounding the *black heart* was clearly marked and of about the same depth as is characteristic of American, black heart, malleable castings. During successive anneals up to the seventh, this ring increased in depth while the black center decreased in area. By the end of the eighth anneal all appearance of the graphitic center had disappeared and the nature of the fracture of the eighth, ninth and tenth bars remained practically unchanged in surface characteristics. The surface was uniformly gray in color and fibrous in texture, and no portion had developed a decidedly crystalline condition.

Analyses of Bars.

The record of the analytical determination is given in Table II, beginning with the white iron previous to annealing and ending with the samples from the eighth bar. It will be recalled that four samples were taken from a 1-inch square bar after each anneal in such a manner as to remove the metal from successive layers, 1/16 inch in depth. The difference in the composition of the samples from each bar represent therefore the differences in the metal and various depths extending from the surface to ¼ inch below the surface. In commenting upon the results of the analyses it may be stated that some difficulty was unexpectedly experienced in obtaining perfectly uniform values for the phosphorus and manganese, as well as the carbon, and the values recorded are the averages of several determinations upon each sample. The difficulty with the carbon was no doubt due to the fact that each sample represented a layer of very material depth, while the changes in composition proceeded continuously from the surface inwardly, resulting in a gradual elimination of that element. It was not easy, therefore, to obtain a perfect mixture of the particles of each sample. The work on the phosphorus and manganese, however, seemed to indicate that, while there was no elimination or increase of either element, there might be a difference in the character of the state of combination, from point to point, sufficient to interfere somewhat with the obtaining of perfectly harmonious estimations. The cause was, however, not further investigated.

It will be seen from the table that the percentage of silicon remained practically unchanged throughout the series and that this obtained also with the phosphorus and manganese, while there was a gradual increase of sulphur from the surface inwardly due to absorption from the packing and the oven gases. In the surface layer this increase raised the sulphur from 0.045 per cent in the white iron to 0.080 per cent after the eighth anneal and the layer ¼ inch below the surface had attained at this stage a maximum of 0.056 per cent. In the case of the carbon the original amount, 2.35 per cent, was somewhat lower than some authorities consider satisfactory practice. We have, however, observed that excellent results may be attained with a percentage even somewhat lower than this figure if the conditions of the anneal are properly adhered to. After the first anneal, practically all the carbon had been changed into the graphitic state, although, oddly enough, there remained in the outer layers, but not in the center, a considerable percentage of combined carbon. This may have been due to some chilling action at the time that the pieces were taken from the oven. After the second anneal, however, all carbon remaining was in the graphitic condition and there was a gradual and progressive elimination until, after the eighth annealing, only 1.40 per cent remained in the layer ¼ inch below the surface. While analyses were not made upon samples from the ½ inch round bars,

Table II.

ANALYSES OF SAMPLES FROM SQUARE BARS.

Anneal No.	Sample No.	Silicon, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Manganese, per cent.	Total carbon, per cent.	Graphitic carbon, per cent.	Combined carbon, per cent.
White iron	—	0.75	0.045	0.175	0.144	2.35	——	——
1.	1.	0.74	0.051	——	0.140	1.25	0.52	0.73
	2.	0.76	0.051	0.179	0.144	1.82	1.59	0.23
	3.	——	——	——	——	——	——	——
	4.	0.73	0.046	0.179	0.149	2.21	2.20	——
2.	1.	0.72	0.070	0.177	0.151	0.178	0.172	——
	2.	0.71	0.051	0.186	0.147	1.53	1.54	——
	3.	0.74	0.049	0.182	0.153	2.17	2.16	——
	4.	0.71	0.049	0.169	0.151	2.24	2.22	——
3.	1.	0.76	0.061	0.180	0.143	0.18	0.20	——
	2.	0.76	0.060	0.180	0.146	1.34	1.32	——
	3.	0.73	0.054	0.185	0.149	2.17	2.16	——
	4.	0.73	0.054	0.183	0.148	2.31	2.34	——
4.	1.	0.73	0.068	0.168	0.137	0.10	0.11	——
	2.	0.76	0.054	0.165	0.138	1.08	1.05	——
	3.	0.75	0.055	0.184	0.141	2.13	2.12	——
	4.	0.74	0.055	0.181	0.134	2.30	2.30	——
5.	1.	0.72	0.072	0.172	0.136	0.12	0.09	——
	2.	0.77	0.060	0.181	0.136	1.01	1.02	——
	3.	0.78	0.060	0.178	0.138	1.96	1.91	——
	4.	0.76	0.060	0.182	0.142	2.19	2.12	——
6.	1.	0.77	0.070	0.177	0.142	0.17	0.19	——
	2.	0.74	0.060	0.185	0.142	0.87	0.90	——
	3.	0.76	0.060	0.173	0.136	1.79	1.62	——
	4.	0.76	0.056	0.168	0.142	1.64	1.64	——
7.	1.	0.76	0.072	0.187	0.142	0.05	0.05	——
	2.	0.77	0.060	0.178	0.155	0.60	0.54	——
	3.	0.78	0.060	0.183	0.140	1.29	1.41	——
	4.	0.75	0.060	0.171	0.151	1.55	1.59	——
8.	1.	0.74	0.080	0.168	0.151	0.06	0.06	——
	2.	0.75	0.060	0.177	0.152	0.63	0.48	——
	3.	0.75	0.060	0.182	0.151	1.40	1.37	——
	4.	0.75	0.056	0.178	0.151	1.37	1.39	——

it is probable that much less than this percentage of carbon remained at their center after the eighth anneal, although the distance from the surface was ¼ inch. This might be expected, however, from the fact that no reservoir of carbon still deeper was left to draw upon, as there was in the case of the 1-inch square pieces.

In conclusion, it may be repeated that the main feature of this investigation was the illustration of the fact that extended or repeated annealing is not necessarily injurious to the quality of the resulting metal.

Large Machine-Molded Cores

JOLT-RAMMING molding machines are not only adapted for the production of molds, but are now being extensively used for making cores. The economies that can be effected increase according to the size of the core and in the foundry of the General Electric Co., Schenectady, N. Y., large cores are successfully made in this way. Three Norcross jolt-ramming molding machines, built by the Arcade Mfg. Co., Freeport, Ill., are used exclusively on this class of work and the accompanying illustrations clearly show the sizes of the cores that can be successfully rammed in this way. The three machines have 8, 12 and 20-inch cylinders, respectively. Fig. 1 shows three large cores, the one at the left weighing 5,000 pounds and is 5 feet long, while the core in the center weighs 2,500 pounds. The core at the right, it will be noted, has a diameter of 8 feet, 6 inches.

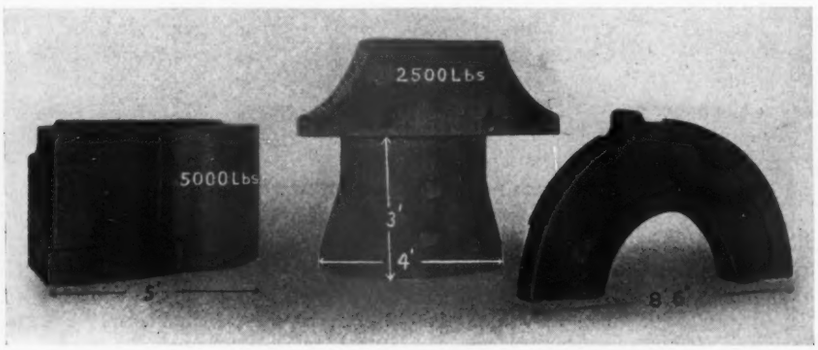


FIG. 1—LARGE CORES MADE ON A JOLT-RAMMING MOLDING MACHINE

In Fig. 2 are shown cores for a 20,000-kilowatt condenser base made on a jolt-ramming machine. The cores weigh respectively, 800, 3,000 and 4,000 pounds, the latter two being 7 feet long and 3 feet high and 5 feet long, 3 feet, 6 inches high.

In Fig. 3 are shown two large cores for a generator base mold weighing 5,000 pounds each, while the core shown at the top of this view weighs 800 pounds. Cores for a 20,000-kilowatt condenser base made by a Norcross jolt-ramming machine are also shown in Fig. 4. These cores vary in height from 6 feet to 6 feet, 7 inches and in weight from 1,000 to 1,500 pounds. In practically all of the cores cinders are rammed in the center to insure free venting. Two large cores for a generator base recently made, weighing 5,600 pounds each, were made at a cost of $1.60 each. When rammed on the floor these cores cost $9.00 each to produce and the saving thus effected by molding them on a jolt-ramming machine was $7.40 for each core.

Cast Copper of High Electrical Conductivity*

THE production of pure copper castings, mechanically sound and possessing an electrical conductivity comparable to that of pure forged copper, has been an important problem ever since the development of electrical machinery and apparatus. The patent office files are replete with descriptions of methods for producing this result, and secret compositions warranted to produce copper castings of high conductivity have been sold for some time, and there are but few foundry foremen who do not claim to have obtained the desired result by adding phosphorus or some similar material. Copper castings of high conductivity, however, have obstinately refused to become a foundry product and it may be assumed there are good reasons for it. The cause of the difficulty in producing such castings has been well understood for some time. Molten copper has the property of dissolving gases, such as oxygen, and of setting a part of these gases free on cooling. This produces pin holes and even big cavities, and the casting, therefore, is mechanically unsound and has naturally a low electrical conductivity. The elimination of these dissolved gases presents little difficulty by means of the well-known deoxidizers, such as zinc, magnesium, phosphorus, etc., which are added in small quantities to bind the oxygen chemically. Copper castings, free from blow-holes, are thus easily produced, but the electrical conductivity of the copper, as a rule, is low, because all of the deoxidizers used also have the property of combining with the copper, and the remarkable rate at which the conductivity of the copper drops when small amounts of impurities are alloyed with it, is well known.

*Abstract of a paper presented by Dr. E. Weintraub of the West Lynn (Mass.) research laboratory of the General Electric Co., at the Chicago meeting of the American Electrochemical Society.

Elimination of Oxygen.

The amount of oxygen dissolved in copper during the process of melting is a variable quantity, and is distributed throughout the whole mass. It is, therefore, practically impossible to add the deoxidizer in such a way as to eliminate oxygen complete, without, at the same time, alloying

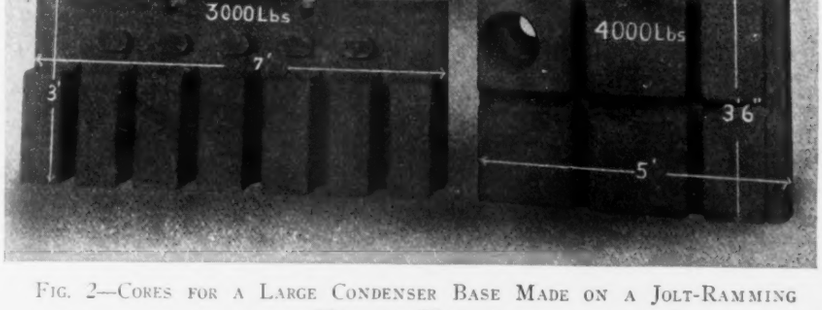


FIG. 2—CORES FOR A LARGE CONDENSER BASE MADE ON A JOLT-RAMMING MOLDING MACHINE

it to a certain degree with the copper. In the laboratory good results have sometimes been obtained, but they are hard to duplicate and the transfer to the foundry has always been a disastrous experiment. To find a satisfactory solution of this problem it is necessary to find a deoxidizer that has no affinity for copper when molten, and which, therefore, could be added in excess with impunity. It occurred to Dr. Weintraub that boron, which, at the melting point of copper has a great affinity for oxygen, nitrogen, etc., should be an ideal substance for deoxidizing copper, but as pure boron at present may be too expensive, he decided to use an amorphous powder that he had discovered in previous experiments and named it boron suboxide. This substance is prepared by a modification of the reduction process of boric anhydride by magnesium and contains as an impurity, only a small percentage of oxygen. Obviously, for the purpose of eliminating oxygen from copper without introducing any impurity capable of alloying therewith, this boron suboxide would be as good as pure boron, or even better, because it is obtained in the form a very fine powder. An experiment was made and the first trial was successful, 0.1 per cent of the suboxide having been added to the copper. A perfectly sound bar was made with a conductivity of 94 per cent. Further experiments showed that the amount of suboxide could be reduced to 1/30 of 1 per cent and also that the addition of a large excess up to 1 per cent did not, in any way, diminish either the conductivity or the mechanical properties of the cast copper. This method, therefore, could be given to the foundrymen, as it always gives good results, providing the copper is pure.

Pure boron suboxide, however, is somewhat difficult to obtain, as the direct result of the reaction attending the reduction of boric-anhydride by magnesium the first being in excess, is a mixed product consisting of magnesium borate, boric anhydride, and boron suboxide, and if it were necessary to isolate the latter, the mixture would have to be submitted to chemical treatment, which would greatly increase its cost. It was found, however, that the mixture gave as good results as the pure suboxide, as both the magnesium borate and boric-anhydride were harmless, and that it was only necessary to use enough of the mixture to add the requisite amount of the boron suboxide to the copper. Thus, the expense of purification is avoided and the only preparation required is to grind the product of the reaction into coarse grains, the increased bulk of the material being an advantage, if anything, as it can be better handled by the foundry scales.

The present practice is to add 1 to 1½ per cent to the copper, which is equivalent to 0.8 to 1 per cent of boron suboxide, which confers the following properties upon the copper: The electrical conductivity can be as high as 97½ per cent if the copper is perfectly pure, but in the foundry, where scrap copper is frequently used and the material cannot be carefully selected, a conductivity of 90 to 95 per cent is obtained and a guarantee of 90 per cent is given. The resulting castings can be readily machined and the mechanical properties are as follows: Tensile strength, 24,350 pounds per square inch; elastic limit, 11,450 pounds per square inch; elongation, 48.5 per cent; reduction in area, 74.49 per cent. Castings are made in all shapes and sizes with no more difficulty than in the case of brass and the cost of boron is small, as at the present price of magnesium and boric anhydride the cost per pound of copper is less than three-fourths of a cent. The success of this process has suggested new lines of work, such as the addition of boron to copper alloys and the replacing of the poling operation of refining copper by a boronizing operation.

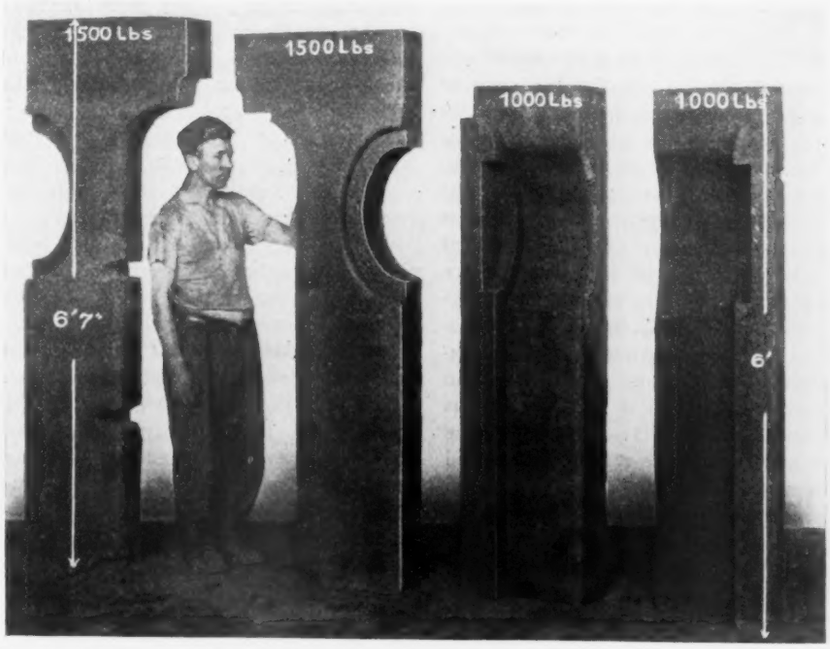


FIG. 4—CORES FOR A 20,000-KILOWATT CONDENSER BASE MADE ON A JOLT-RAMMING MOLDING MACHINE

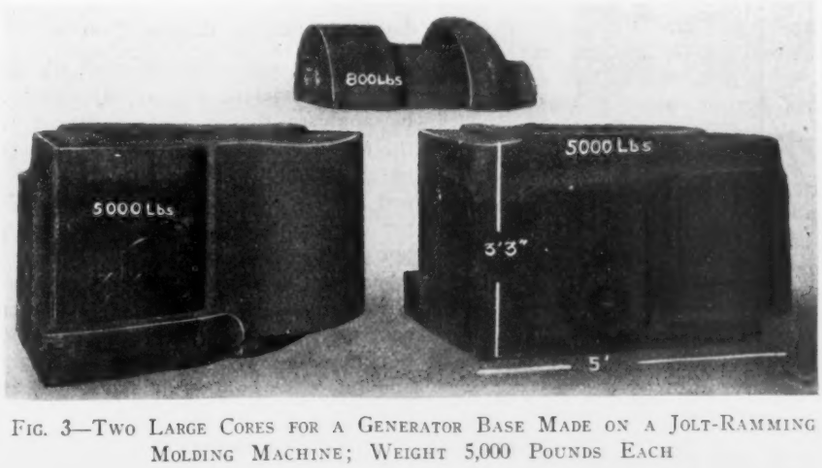


FIG. 3—TWO LARGE CORES FOR A GENERATOR BASE MADE ON A JOLT-RAMMING MOLDING MACHINE; WEIGHT 5,000 POUNDS EACH

An anti-friction alloy patented by Joseph R. Stratton, New Brunswick, Can., and supposed to be suitable for railroad and other heavy service, is as follows: Copper, 1.7 per cent; tin, 5.8 per cent; lead, 9.8 per cent; zinc, 82.0 per cent, and antimony, 0.7 per cent.

UTILIZATION OF CAST IRON BORINGS

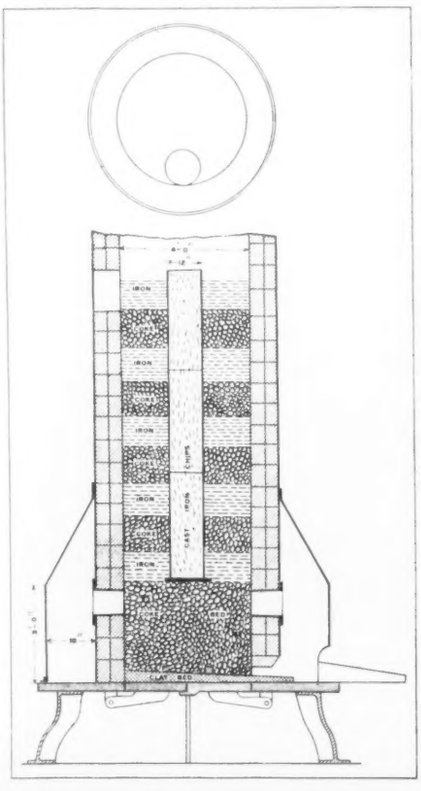
Excellent results obtained from the Prince process of charging borings in the cupola--Beneficial effects on the iron

By John Jacobson

THE utilization of gray iron borings, turnings and drillings is now receiving considerable attention, and as a result of these experiments a number of methods have been developed that insure the recovery of a large amount of metal from this scrap, which in the past has been of little value to gray iron foundries. When shoveled into the furnace the losses are exceedingly heavy, as most of the fine particles are blown out of the stack and those that remain are easily oxidized. The method of charging in pine boxes, holding approximately 100 pounds, has also been extensively tried, but the objection against this method is that the box is consumed before the chips reach the melting zone and the material is carried down with the charge in a loose form and is easily oxidized. A similar objection is made against the use of cast iron boxes, or any material that melts at a lower or the same temperature as the chips. In Europe a process or briquetting by a hydraulic press, has recently been introduced and good results have been obtained. However, the cost of briquetting is reported at approximately $6.00 per ton, which is excessive for scrap of this nature. Various binders are also used and considerable success has been attained with cement and similar materials that will hold the scrap in a bonded condition until it reaches the melting zone and thus obviates the oxidation of the small cast iron particles. Iron absorbs sulphur in proportion to the surface exposed to the gases, and the surface area thus exposed on cast iron chips is greater than on any other class of scrap.

Successful Use of This Scrap.

At the Henry R. Worthington plant, Harrison, N. J., this scrap is used daily with excellent results by a new process invented by F. H. Prince. This consists of the use of a wrought iron or steel tube, approximately 12 inches in diameter, made up of sections about 3 feet long, crimped on one end, similar to stove pipe, to allow the ends of the pipe to fit into each other. The tubes are made of either No. 22 or No. 24 gage steel, and the temperature required to melt them is from 600 to 800 degrees Fahr. higher than that required to melt cast iron. The method of placing these sections in the cupola and charging with the borings, turnings, etc., is shown in the accompanying illustration. The coke bed is charged as usual and a cast iron plate, 13 inches in diameter, is set on top of the coke, close to one side of the cupola and if possible between the tuyeres. The first tube is placed on this plate and is filled with chips, and other sections are added until they reach the height of the charging door. A special door is provided for this purpose, which is cut into the cupola at a point in the stack where it will not interfere with the charging of the coke, pig iron and scrap. However, the regular charging door can be used, but it is not as convenient as a special door for this purpose. As the charges settle, the tubes settle with them and new sections are continually added and filled with chips, throughout the entire heat. The steel pipe effectively protects the material from the cupola gases, and before the tube melts the chips have passed into a fused or molten state. These tubes can also be used as mixing chambers for the introduction of alloys, such as ferro-silicon or ferro-manganese.



PLAN AND CROSS-SECTION OF CUPOLA, SHOWING METHOD OF CHARGING BORINGS

Increased Tensile Strength.

Tests to ascertain the results of the use of this scrap on the iron show that the tensile strength is increased and the grain is closed without an increase in hardness. From 8 to 15 per cent of chips are being used with charges of 45 per cent pig iron and 55 per cent scrap. The tensile strength shows an increase of from 3,000 to 5,000 pounds per square inch and a soft mixture for light machinery castings gave a tensile test result of 33,000 pounds per square inch.

Low Losses.

We have made comparative tests of cast iron from heats with and without chips, and found the average losses to be from 4 to 5 per cent. One test to ascertain the total loss in melting this material showed a net loss of only 4.6 per cent in a heat of 10 tons of chips. It is evident from the good results obtained at the Henry R. Worthington plant, after a period of two years, that borings, drillings, etc., are not only of advantage on account of their low price, but are to be recommended for the great benefits derived from their use in the mixtures, imparting properties to the iron that are beneficial. During the past two years that we have been using this material at this plant, we have melted from 200 to 300 tons per month.

Reduction of Carbon Content.

As to the effects of the chips on the resulting material, we have ascertained by analyses that a loss in excess of the regular loss in melting, occurs only in the carbon. For instance, in the test heat in which we melted about 20 per cent chips, we found the total carbon to be 2.89 per cent. This iron, when none of the chips was used, usually analyzed from 3.20 to 3.40 per cent total carbon. Of course, it would be impossible to state what the exact amount of carbon would have been in this test heat if no chips had been used, but we have always found less

total carbon in heats containing borings, etc., then those in which none of this material is charged. The closeness of the grain also confirms this.

First Test Heat.

When we first introduced this process we made two test heats to determine the practicability of melting this material with our regular heats. The first test heat was made in a cupola 42 inches diameter and the charges consisted of the following: Pig iron, 6,065 pounds; scrap, 7,900 pounds, and cast iron chips, 3,500 pounds, or approximately 20 per cent of the mixture. A total of 17,465 pounds of iron was charged. All of the material was run into pigs and was weighed on the same scales as that used for weighing the charges. The total amount of metal melted was found to be 16,600 pounds, a loss of 805 pounds, or 4.6 per cent. Six test bars, 1 inch square and 12 inches long, were cast from different parts of the heat and the two bars cast from the first part of the heat showed tensile strength results of 29,900 and 29,800 pounds per square inch, respectively. Two bars from the middle of the heat tested 25,410 and 27,400 pounds per square inch, respectively, while the two bars cast from the last part of the heat gave tensile test results of 25,800 and 26,000 pounds per square inch, respectively. Hardness tests of the bars from the first part of the heat gave 360 revolutions, middle of the heat, 285 revolutions, and last part of the heat, 305 revolutions. The hardness tests were made as follows: A 5-16-inch twist drill was weighted on the feed by a constant weight and the drill was permitted to feed through the test bar by the weight, and the number of revolutions required to drill a 1-inch bar was noted. The drills were changed as soon as they showed any indications of becoming dull.

Second Test Heat.

The second test heat was made in a cupola, 66 inches inside diameter, and the charges consisted of pig iron, 14,254 pounds; scrap, 15,718 pounds, cast iron chips, 3,561 pounds, and the total amount of metal charged amounted to 33,533 pounds. About 27,000 pounds of this metal was run into three flat plates, which were carefully weighed after cleaning, and after weighing the remainder of the metal, it was found that a total of 32,258 pounds of iron was tapped out of the cupola, showing a loss of only 1,275 pounds or 3.8 per cent.. Test bars cast from different parts of this heat, similar to those taken from the first heat, gave the following results: Two bars from the first part of the heat had a tensile strength of 29,800 and 29,900 pounds per square inch, respectively; the hardness test, 355 revolutions. Two bars from the middle of the heat showed a tensile strength of 33,900 and 32,900 pounds per square inch, respectively, and hardness test, 345 revolutions. From the last part of the heat the two bars showed a tensile strength of 29,000 and 29,200 pounds per square inch, respectively; hardness test, 365 revolutions. The hardness tests were taken as in the first heat. The standard bars of the regular heats from this cupola give tensile strength results of from 24,000 to 26,000 pounds per square inch and the hardness tests vary from 300 to 400 revolutions per inch. The standard iron from the cupola in which the first test heat was made gives tensile strength results of from 23,000 to 25,000 pounds per square inch and a hardness of 325 to 375 revolutions per inch.

Other Tests.

We have also made several tests charging the furnace for two or three charges without chips and using the tubes filled with this scrap in the fourth charge. Test bars from each part of the heat showed that those cast from the metal containing these chips always gave an increase in the tensile strength of from 3,000 to 5,000 pounds per square inch. The grain of the bar cast from metal not containing chips was close around the edges and more open toward the center, where it showed a crystalline fracture, as is usual with a slowly cooled bar containing approximately 2.50 per cent silicon. The bars containing the chips, however, were uniformly close-grained throughout. The analyses showed a very small variation of all the elements, with the exception of carbon, which is from 0.20 to 0.35 per cent less in the bars containing chips.

Metal for High Pressure Castings.

We also used cast iron chips on high pressure work, where we formerly employed semi-steel mixtures, and we find that our metal withstands the pressures equally well. As the chips are protected from the direct action of the gases by the steel tube during the process of melting, they cannot become oxidized or absorb sulphur from the fuel. Yet, the borings being in such a fine state, a great deal of the graphitic carbon is lost during the process of melting, thereby reducing the percentage of total carbon without increasing the percentage of the combined carbon. Thus, the grain of the iron is made closer by the reduction of the total carbon, while the hardness is not increased, since the combined carbon is not increased. This is not the case when using steel for closing the grain of iron. It is introduced for the purpose of lowering the total carbon. The combined carbon is increased and there is a reduction of silicon in the mixture and an increase of sulphur. Steel, when it is melted in the cupola, will absorb a greater percentage of sulphur than cast iron, as it requires a much higher temperature to melt it and an increased amount of fuel must be used.

Advantages of Prince Method.

Carbon is the element which controls the hardness of cast iron and the hardness is proportional to the percentage of combined carbon. The higher the combined carbon, the harder the iron. When using chills the reduction of the graphitic carbon is always accompanied by an increase of combined carbon. The chills merely prevent a part of the combined carbon from separating out into the graphitic state. However, when using cast iron chips by the Prince method, a part of the graphite is lost, the silicon content of the mixture remains unchanged and there is no absorption of sulphur in melting, as is the case when melting steel in the cupola. The combined carbon is, therefore, not increased. Steel reduces all the impurities, except the combined carbon and sulphur. The graphite-separating elements being reduced, the carbon remains in the combined state, whereas, when using cast iron borings only the graphitic carbon is reduced and the graphite-separating elements being unchanged, part or the remaining combined carbon is separated out into the graphitic state, effecting a reduction in both the graphitic and combined carbon, thereby closing the grain without increasing the hardness of the iron.

Chromium Alloy

A new alloy of copper, nickel and chromium, invented by John Scanlan and James Naulty, of Philadelphia, is said to be as hard as ordinary steel and is suitable for edge tools. The alloy is made by melting 5 pounds of chromium with 5 pounds of aluminum, which is used as a flux. When this is melted, 110 pounds of copper are added, then 25 pounds of nickel and, finally, 20 pounds of zinc. The proportions of the constituent metals, it is stated, can be varied, but the order in which they are added and the use of aluminum as a flux, are essential. The alloy has a red color and a tensile strength of 78,950 pounds.

THE BRASS FOUNDRY

Blemishes on Brass Castings

By C. Vickers

THE external appearance of a casting is an important factor governing its sale, and the more nearly it conforms to the pattern the more satisfactory it will be, other things being equal. The latter qualifying statement may be taken as conveying the impression that a close resemblance to the pattern is not all that may be expected of a casting, however desirable this may be, because it can appear to be perfect and under its fair skin, resemble a sponge, or, while conforming in gentral outline to the pattern, its surface may be rough and unsightly. It follows, therefore, that a casting to be perfect must not only show no deviation from the pattern, but must also be sound throughout and as smooth of surface as its weight will permit. A heavy casting cannot be produced with as smooth a surface as either a small or large, thin casting, because the sand has to be coarser to permit of the free escape of gases, which, if retained, would cause scabs, buckles, blow-holes and other imperfections. Therefore, a jobbing foundry equipped to handle all classes of castings, will find several grades of sand necessary for the proper conduct of its business, as the floor for heavy work will require a coarse grade, similar to what is used on side floors for iron. The tubs, benches, or molding machines, will require a smoother grade suitable for handling miscellaneous castings up to 100 pounds in weight, while for fine pattern castings, name plates, or work of a decorative character, a sand, so fine and smooth as to be almost an impalpable powder, will be necessary. These fine sands are considerably more expensive than the ordinary grades, as in many cases they are artificially prepared by drying, sifting and bolting, to eliminate all coarse particles and organic matter that would produce a rough surface on the casting. The results justify the expense, as the additional expenditure for sand is more than compensated for by the saving effected in finishing.

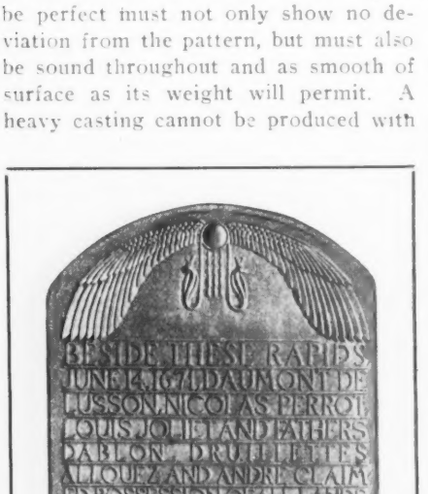

BESIDE THESE RAPIDS
JUNE 14, 1671 DAUMONT DE
LUSSON, NICOLAS PERROT,
LOUIS JOLIET AND FATHERS
DABLON, DRUILLETTES
ALLOUEZ AND ANDRE CLAIM
ED POSSESSION OF ALL LANDS
FROM THE SEAS OF THE NORTH
AND WEST TO THE SOUTH SEA
FOR LOUIS XIV OF FRANCE. IN
1763 THE LAKE REGION WAS
CEDED TO ENGLAND AS A POR
TION OF CANADA. AT THE
CLOSE OF THE REVOLUTION
SAINT MARYS RIVER BECAME
PART OF THE NATIONAL BOUND
ARIES. IN 1797 THE NORTH
WEST FUR COMPANY BUILT
A BATEAU CANAL AND LOCK
ON THE CANADIAN BANK. IN
1820, LEWIS CASS, GOVERNOR
OF MICHIGAN TERRITORY,
HERE ESTABLISHED THE AU
THORITY OF THE UNITED STATES
FROM THE GREAT LAKES TO THE
MISSISSIPPI RIVER.

FIG. 1—HISTORICAL BRONZE MEMORIAL TABLET

Fine Brass Work.

Fig. 3 shows an ornamental plate cast in yellow brass, and it will be noted that every line of the pattern is faithfully reproduced. The mold was made from an embossed card and the thickness was obtained by the method outlined on page 7 of THE FOUNDRY, Sept., 1910. The only finishing treatment the casting received was an accidental tumbling in a wet barrel, which, however, did not injure it, as the tumbler was well packed. Figs. 1 and 2 show two bronze memorial tablets which are illustrations of large, thin work, and which are interesting because fine castings must be produced with a view to reducing the expense of finish to a minimum. They were cast by the W. H. Jackson Co., New York City, and the dimensions were 5 feet, 6 inches long and 2 feet, 8 inches wide. The metal was a standard statuary bronze containing a larger percentage of zinc than is usual in such castings and which, owing to the smoke evolved, would, to some extent, increase the difficulties of casting. The formula was as follows: Copper, 90 per cent; zinc, 7.5 per cent, and tin, 2.5 per cent. The illustrations show the finished tablets and not as taken from the sand, but it will be evident that the production of such work demands a high degree of skill in molding. The method of making them is to first produce a perfect pattern by casting a bronze plate without letters. This is finished off and the letters, which have been separately cast and finished, are attached thereto. The tablets are then cast from this pattern, which will not bend and spring the same as a wood model. It hardly

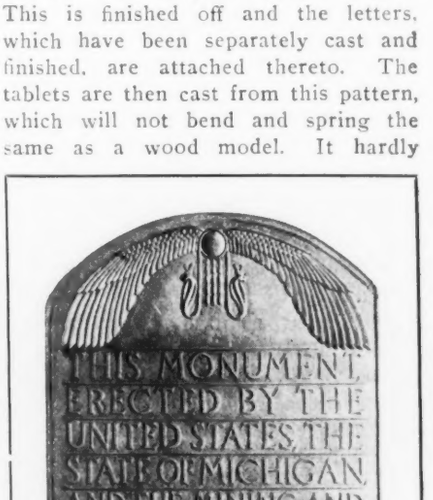


FIG. 2—ANOTHER BRONZE MEMORIAL TABLET

seems necessary to state that when first class work is demanded, first class patterns must be provided, and this is especially true of such work as these tablets. Although only four castings were required, the patterns were made with the same care as when intended for continued use.

The Sand Problem.

The brass founder, who has always been in the habit of making light castings, will generally have only one grade of sand in the shop, which, of necessity, will be as fine as is possible to obtain without incurring the extra expense of prepared sand. Consequently, he will not be in a position to undertake the production of castings over 100 pounds in weight or pump liners and similar circular work that must be made in deep molds. In making high grade castings, therefore, a proper selection of sand is all-important. This point is not as well understood as might be imagined, and has frequently proved a stumbling block in the path of small concerns that have accepted patterns of heavy work which they expect the foundry to make in sand adapted only for small castings. When failure and losses result, it is found difficult to understand why it should be necessary for the molders to use facing sand, molasses water and resort to skin drying, when a neighboring shop would turn out the work in one-half the time without these precautions. The trouble is all due to the sand. It may be mentioned that all fine sands do not behave alike when used for making a variety of castings. Some sands are both fine and smooth, and yet free-venting, and can be used with impunity for work which another sand, of the same degree of fineness and general appearance, would utterly fail to produce without considerable venting, facing, spraying and baking. It may be taken as a rule, that when a fine sand, after it has been burnt black, no longer absorbs water readily, that it is unfitted for any but very small castings, and that it will be greatly improved by frequent additions of new sand. As might be expected, the rough casting is the easiest to make and can be said to represent the starting point from which all subsequent progress toward perfection is directed. This is the reason why the first few castings of a new and difficult pattern frequently reach the scrap pile instead of the customer, and this educational process is known to the molder as "getting his hand in."

Other Imperfections.

Between the two extremes of what is known as a rough casting and its opposite, a fine one, are many degrees of imperfection which are frequently justified by such statements as, "the sand was too coarse," "the sand was too close," "the metal was poured too hot," "a piece of the poker, or the skimmer broke off and was lost in the metal," etc. However ridiculous such excuses sometimes are, they really are a fruitful source of defects and roughness in castings, and should be avoided by all possible means. Pouring the metal too hot and the presence of iron are both responsible for unsightly bronze castings, although the former error does not produce the same ill-effects on heavy work as on light castings embellished with ornamental designs. In the latter case, even when the pattern has been printed back and the mold skin dried, the metal is liable to produce fins on the top of the scrolls, or high portions, which, when removed, leave scars. There is also considerable danger of straining the mold and making the castings too heavy and out of proportion, consequently, the ability to judge the proper temperature at which to pour is as necessary as the selection of suitable sands.

For heavy castings, as previously stated, hot metal is not always an evil, as there are castings that must be poured hot to avoid shrinkage at certain points. In such cases, the mold should be rammed solid and even, without soft spots, and the sand should be free so as to be largely self-venting, while the mold should be well slicked with plumbago. The casting should be shaken out at a red heat and dressed before it cools, as in all probability the metal will be found to have penetrated the sand, particularly at square corners, on the bottom and the lower part of the sides. The corners will often be "ornamented" with a fin which is easily rasped off when the casting is hot, while on the bottom and sides the surplus metal may be compared to a metallic moss which is easily detached when hot with a chisel or spade, but which is very difficult to remove when cold, as it clings tenaciously, and being half metal and half sand is difficult to cut, as it takes the edge off the tools. It may be stated, however, that it has nothing in

FIG. 3—CASTING MADE IN YELLOW BRASS FROM AN EMBOSSED CARD

common with a scab. A heavy casting, dressed while hot, can, with a little energetic work, be made so presentable that little remains to be done when cold to prepare it for shipment.

When heavy masses of bronze are cast around cores of small diameter, the metal will frequently penetrate them, filling the hole with a mass of mingled sand and metal which sometimes cannot be removed, even when the castings are hot, and when they are cold it is an expensive operation to drill them out. To avoid this trouble as much as possible, the cores should be made of a highly refractory sand, such as silica sand bonded with linseed oil, and coated with one or more coats of good plumbago mixed to a dough with weak molasses water, and smoothed on with the fingers in preference to being painted on, whenever the shape of the core will permit.

Composition of the Metal.

The composition of the metal also has a great influence on the appearance of the castings, irrespective of whether it is contaminated with iron or not, for if a copper-tin alloy also contains a high percentage of zinc, it will be found very difficult to produce attractive castings. This is due to the influence of zinc in decreasing the casting properties of an alloy, an influence that is greatly increased by the presence in quantity of either tin or lead. When tin predominates in a mixture, the amount of zinc should be low, and no more used than is necessary to deoxidize the metal, which may be 2 or 3 per cent, and for massive castings it can be advantageously omitted, and some other deoxidizer be substituted, such as phosphorus, magnesium or manganese. The foregoing statements do not apply to the physical qualities of the castings, and when clean castings are desired, it will be found advisable to reconsider the use of formulas high in both tin and zinc, as otherwise they may be marred by a strongly adhering dust, which, on parts where the pressure has been greatest, will often become a scale concealing a blemish, while the upper parts of the casting are liable to possess cavities filled with green oxide. This applies most particularly to the copper-tin alloys used for machinery castings and which, generally, contain 6 per cent and upwards of tin. In these mixtures the tin is sufficiently high to produce a bronze, which, if skillfully made, is capable of producing dense, solid castings of the requisite hardness and tenacity, without any further admixture of other metals. To do this in every case, however, requires more skill than the average furnace man possesses. To obtain the best and most uniform results it would be necessary to bring the copper, when melted, to the tough-pitch state before alloying the tin, otherwise it would frequently happen that porous castings would result, as tin does not act as a deoxidizer of the copper to any extent. Consequently, it was found advantageous to incorporate zinc with these alloys, as for example in the case of the so-called government gun metal—copper, 88 per cent; tin, 10 per cent, and zinc, 2 per cent. This latter metal acts as a deoxidizer to prevent the too frequent occurrence of spongy castings. The quantity used, however, is not sufficiently great to permit of any neglect in melting the copper for this alloy, as unsound castings can be very easily produced, more so than when the amount of zinc is still further increased, so that it is largely due to this fact that zinc is found as a general constituent of bronze. There is a limit to its use, however, beyond which its cheapening influence will be more than offset in the case of heavy castings, by the increased difficulty of obtaining satisfactory work.

In the case of the gun metal referred to, experiments, which the writer has conducted, have proved that the addition of either phosphorus or magnesium, effects a considerable improvement and that the two deoxidizers are about equal in their effects on the alloy. The magnesium, however, should be first alloyed with the zinc, as a very small proportion only is required, from ¼ to ½ ounce to 100 pounds of bronze. The phosphorus was added as phosphor-tin, 1 per cent of which was used. Alloys in which zinc predominates are capable of producing excellent castings, providing the tin and lead contents are both low. Thus, for instance, an alloy of copper, 85 per cent; zinc, 10 per cent; lead, 3 per cent, and tin, 2 per cent, makes excellent thin, or light weight castings, but it will not produce as clean, heavy castings as a copper-tin mixture, because, as the metal slowly rises in the mold, the zinc is oxidized and little white flakes, resembling snow, gather on the rising surface, and zinc fumes are also given off which condense on the cope and sides of the mold and produce the well-known streaked and wormy appearance. The zinc flakes are also frequently folded in and pressed against the sides of the mold, thus forming depressions in the casting filled with a white powder. All this, of course, does not always happen, but when it does, it is very annoying and unless the cause is known, is difficult to remedy.

Iron is another beauty-destroying element that must be constantly guarded against, as it is very easily introduced, especially when scrap copper wire is used. Its presence is indicated by black patches, spots and shrink cavities, and when in considerable quantity, by a cast iron appearance of the castings. Iron, however, can generally be detected while the metal is being skimmed, so that if the appearance of the castings is important, the molds can be saved, as the metal intended for them can be ingoted, or poured into some less important work, or work that can be improved by tumbling. The danger of iron trouble is always present when scrap copper wire is used, whether purchased cabbaged or not, as it is very easy for copper-plated iron, or steel wire, to escape observation, and when it does it generally lands in the pot where it will do the most harm. Consequently, it is always advisable, when about to cast work that should look well, to keep a watchful eye for indications of iron when skimming the pot. These indications are pretty well known, but it may be observed that they consist of the continual formation of black blisters on the surface of the skimmed metal. These blisters unite and in a short time form a crust, which can be skimmed off, but will immediately reform so that the operation of skimming can be carried on until the metal sets, and if the patience permits the skimming operation to be repeated a couple of remelts, most of the iron can be removed in this manner. Occasionally, when the brass is hot, the iron shows itself in the shape of a stream of sparks. Steel generally causes this display, and a little groping with the skimmer will generally result in the offender being fished out in a white hot sparking condition, but the skin color of the brass will then have been spoiled.

As far as is known, no analysis of the skimmed-off material from these blisters has ever been made, although it would be interesting to determine just what percentage of iron is contained therein. Iron blackened castings, even when tumbled bright, never appear as bright as they would if the metal had been free from this contamination, so that dipping in acids is sometimes resorted to in order to remove the unpleasant, black color. This is a somewhat troublesome operation, however, as the discoloration is very tenacious and does not readily dissolve. A hot solution, consisting of four parts water to one part sulphuric acid, is sometimes used for this purpose, although the application of the sand blast would probably be the most effective.

Another frequent source of blemishes on heavy bronze castings is caused by the metal washing away the sand, producing the trouble previously alluded to as a scab. This is often called "cutting" and occurs on thin castings as well as those of heavy section. It is a very annoying source of loss, because if the scab is chipped or ground off, not only does the scar remain, but the sand that has been washed away will generally be found in some prominent part of the casting when its presence will be visible. This trouble is essentially a sand trouble and often disappears when a more free-venting sand is used, but it may be also caused by too hard ramming, or the use of sand too dry, as well as by the gate being so placed that the metal strikes a green sand core. The ramming troubles are easily corrected, and when the mold scabs before a gate and the gate cannot be changed, a core can be rammed in at this point for the metal to strike. Very often a facing of one part flour to 20 parts of sand will be found effective in preventing this trouble. This is very useful on thin work, as well as on the bearing parts of driving brasses, rod brasses, etc., when they exhibit a tendency to cut.

Oxidation of Aluminum

As the melting point of aluminum is lower than that of copper and bronze, it cannot be subjected to the same temperatures as these metals without danger of oxidation. This is frequently overlooked. Aluminum is a peculiar metal to melt, as it absorbs a large amount of heat before it becomes liquid, maintaining an appearance of solidity for such a long time compared with other metals that the melter is often deceived and exposes it to the full heat of the furnace without attention, much the same as he would copper. The result is that the first charge melts quickly, reaches a high temperature, and is boiling and bubbling when the melter looks at it. More metal is then charged and the process is repeated until the pot is filled. Castings made under such conditions are very liable to show fine pin holes after they are machined, and occasionally these holes are visible before the skin is broken. This is caused by the absorption of gases during the boiling period, the effects of such treatment being similar to what it would be in the case of copper or brass, only on a smaller scale, because copper alloys melted in this way would be so full of holes that they would resemble a sponge, while aluminum shows only very small holes, sometimes even being so minute as to pass unnoticed through the foundry to damage the reputation of the founder with his customer.

Cause of Pin Holes.

While these holes in aluminum undoubtedly result from the absorption of gases when overheated, they are not, in the writer's opinion, caused so much by oxygen as other gases, such as hydrogen, nitrogen, or their combinations. One evidence of this is the odor which aluminum emits when solidifying, which every molder has noticed, and which is very perceptible when heavy runner heads are setting. This proves that gases have been absorbed and partly given off when the metal sets. It also proves that the gas is not oxygen, because this element is odorless.

Aluminum is a powerful deoxidizing agent. It readily combines with oxygen, forming oxide of aluminum, which is one reason why it is so valuable in making steel castings, as it is five times as active as silicon in eliminating oxygen. It appears reasonable, therefore, that it would deoxidize itself and that no oxygen could exist in melted aluminum in the form of a gas, and it may be owing to this fact that when aluminum castings are porous they possess none of the characteristics of copper alloys, which in such a condition are honeycombed, while the holes in aluminum are small, like pin pricks in the metal.

Deoxidizing Aluminum.

It will be evident, therefore, that it is not possible to deoxidize aluminum in the same manner as bronze, by the use of such deoxidizers as silicon, phosphorus, magnesium, calcium, manganese, etc., and that, if any valuable properties are imparted to aluminum by the addition of small quantities of these elements, this is not due to any deoxidizing effect they exercise.

It is well known that silicon is not a good addition to aluminum, though it is occasionally used to increase its frictional qualities. For most purposes, however, silicon must be carefully excluded. Phosphorus is also occasionally used and possesses some valuable properties in the strengthening of the metal. An alloy that was tried and found to be a good, strong metal, is aluminum, 94.50 per cent; phosphor copper (10 per cent), 1.50 per cent; zinc, 4 per cent.

Magnesium.

Magnesium forms alloys with aluminum, whose principal advantage is lightness, but they are expensive, owing to the high price of magnesium, and it is doubtful if they will ever be used extensively. Magnesium possesses a strong affinity for oxygen and is supposed to be chemically superior to aluminum in this respect, but it does not combine with the oxides of the metals as readily as aluminum. Aluminum, when finely divided and mixed with the oxide of iron, copper or other metals, forms the well known Thermit, and it would naturally be imagined that magnesium could be used to even better advantage than aluminum, because of its greater affinity for oxygen. But it was determined by experiment that magnesium is greatly inferior to aluminum in this respect, as the reaction was feeble and insufficient to produce liquid metal, while a small quantity of aluminum emery wheel grindings reduced a relatively large quantity of copper oxide to the metallic state.

Calcium.

Calcium also possesses greater affinity for oxygen than aluminum, and although chemists would scoff at the idea of molten aluminum being able to reduce calcium from its chloride, experiments seem to indicate that it does. When calcium chloride is used as a flux on molten aluminum, it boils vigorously until most of the water has evaporated, when it settles down to the condition of strongly boiling molasses, and the bubbles as they break spurt jets of brilliant yellow flame—the characteristic calcium color—such as is exhibited by the flaming arc lamp. When small quantities of the chloride of calcium were used, the surface of the aluminum was kept free from mush and it is undoubtedly a valuable flux for this metal. It is inconvenient to handle, because it is so hydroscopic that it largely turns to water when kept in open vessels, and when excluded from the air is perpetually damp, a condition which necessitates caution when using it on molten metal. When small amounts are used, it does not form a cover on the aluminum like melted glass on copper, because it is continually absorbed or evaporated so that it has to be added at intervals if the aluminum is kept in the molten condition for any length of time.

Experiments with Calcium.

In one experiment, 10 pounds of pure aluminum were melted and 4½ pounds of calcium chloride added at intervals, the mixture being vigorously stirred whenever the yellow jets of flame appeared, and when poured, the appearance of the top of the ingots indicated that some change had occurred in the aluminum, as the shrinkage greatly differed from pure aluminum and the metal ran

much more lively. No physical tests were made other than by hammering samples in a vise, but these indicated that the metal had lost nothing in toughness and ductility, which seems to show that calcium can be used in aluminum to advantage.

As aluminum possesses such a powerful affinity for oxygen, it is to be expected that a combination of the two elements will take place while it is being melted. This actually occurs and is responsible for the thick, mushy metal, which is always skimmed off the surface. This mushy condition is caused by the aluminum oxide, which is a grayish powder and becomes entangled with some of the unoxidized metal. It is a comparatively easy matter to remove the oxide from this mushy metal, and this is the only value that a flux for aluminum possesses. It reduces nothing, merely liberates the oxide, so that the pasty metal disappears and the surface is covered with the powdered oxide. One of the best fluxes for this purpose is zinc chloride, and it is extensively used. Many makers of first class aluminum castings never attempt to dissolve the thick aluminum. It is skimmed off at intervals and afterwards sold. In this way they run no risk of having any of the oxide appear in their castings, which would lower the high standard of their goods.

This is one thing the jobbing brass foundryman cannot understand, because he knows that in melting bronze, it would be exceedingly amateurish in the first place to make mushy metal, and a crime to sell it afterwards. Therefore, he feels the same about the thick aluminum and thinks he ought to use it up, when in fact experience shows this condition is to be expected and should be counted as part of the cost of making aluminum castings, especially where high grade work is desirable.

Oxide of Aluminum.

The oxide of aluminum cannot be reduced by any strong deoxidizing metal or alloy that can be used in the crucible furnace. If it could, the production of aluminum would be a simple matter and would not require the high temperature of the electric furnace. The oxide can be disentangled from the metal as previously stated, but this is regarded as doubtful economy by those who make a specialty of aluminum castings, turning out the highest grade of work with the minimum of loss.

Rational Melting.

The porosity of aluminum castings is easily prevented by rational melting. If the metal, while being melted, is subjected to alternate boiling and chilling, it is to be expected that it will be injuriously affected. Our method of melting aluminum is in special furnaces with iron kettles, somewhat similar to a babbitt furnace, and the metal is dipped from the kettles into iron carrying-off ladles or plumbago crucibles. The surface of the molten aluminum is thus observable at all times, the temperature can be regulated as required, and is never allowed to become hotter than is indicated by a blood red appearance, the proper heat for running thin castings being about 1,400 degrees Fahr. Many castings of heavy section can be made to better advantage when the aluminum shows silvery, with only a suspicion of a red tinge.

Brass Foundry Difficulties

SOLVED BY EXPERTS

Tough-Pitch Copper

We would like to know what is meant by tough-pitch copper, and whether this condition can be brought about in the brass foundry? If it can, what would be the advantage, in making either bronze or copper castings?

Copper is said to be tough-pitch when the fractured surface shows a pale red, or salmon-color, silky fracture. The specimen is broken with difficulty. In this condition it has attained its highest degree of malleability and ductility, and, therefore, when copper is pure and tough-pitch, it has been refined to the highest degree.

In the refining of copper the impurities are removed by the fluxing action of cuprous oxide, which is formed by the action of the air on the surface of the bath in the refining furnace. The process is a gradual one, occupying several hours, and consists of the alternate oxidation of the surface, and skimming of the resultant slag, until the impurities are eliminated, and the copper becomes "dry" and shows the characteristic brick-red color. This condition is produced by the absorption of oxide and at this stage the copper has lost, to a marked degree, its properties of ductility and malleability, and has become both cold and red short, and is therefore worthless for either rolling or casting purposes.

The next operation is to remove the oxygen, which is accomplished by the process known as poling. This consists of thrusting back into the bath a long pole of green timber, the gases from which bubble through the liquid metal and carry off the oxygen, the surface of the copper being meanwhile protected from further oxidation by a covering of charcoal. Tests are taken, from time to time, to determine when the copper has arrived at the tough-pitch stage, as it is very easy to carry it beyond this, and produce "overpoled" copper, when it becomes granular, brittle, and red short. Therefore, it is essential that the operation be stopped when the tough-pitch stage is reached, at which point the metal is run into ingots and sets with a level surface, which is the stage to which ingot copper is supposed to be refined. In this condition it is not entirely free from oxygen, but contains neither too much, nor too little, as it seems that a small quantity of oxygen is necessary to produce this condition. This tough-pitch stage, however, is a very delicate condition, which is only permanent as long as the metal is not heated. The operation of melting the copper, therefore, changes this condition, and it becomes underpoled, even when protected by charcoal and melted with the greatest of care. Therefore, the copper does not possess its maximum strength and the bronze is not as strong as would be the case if the copper were at its best. For this reason, all alloys would be better if producetd from tough-pitch copper, and to bring it to this condition it is necessary to pole it in the same manner as is done in the refining furnace. To accomplish this, take a hardwood pole, 2 or 3 inches in diameter, plunge it to the bottom of the crucible, and stir the metal slowly and steadily until a sample will show, on cooling, a small, brown shrinkage hole in the center of the ladle. When it reaches this stage, care should be exercised to prevent increasing the temperature of the furnace, and to continue stirring until another sample will cool with a level surface, which when broke,

shows a close, fine grain. At this stage, if copper castings are to be made, a very small quantity of silicon-copper can be added, and the metal immediately poured. If a bronze is to be made, however, add the alloying metals and then pour as soon as possible, using a liberal supply of powdered charcoal during the entire operation and if possible, when pouring, retain the charcoal upon the surface of the bronze, keeping it from running into the mold by bending the skimmer to fit the lip of the pot. A small, but heavy wrought iron ladle with a suitable handle, will be found convenient in dipping out the samples, and the copper can be allowed to set therein, so that the condition of the surface can be noted. The operation of producing tough-pitch copper in the brass foundry is a somewhat tedious proceeding, so that it is seldom done, but it is undoubtedly an advantage, as by this means better alloys can be produced and spongy castings are prevented.

Tin Babbitt

We would like to obtain a formula for a first-class tin babbitt, suitable for service on street car motor bearings. We desire a metal that will stand up under the most severe conditions, and we believe such an alloy should be both harder and tougher than ordinary tin babbitt, as one of the best alloys we ever tried had a ringing sound when struck, and at the same time was very difficult to break. We have tried to make this alloy, but so far have met with little success.

An alloy, such as you require, can be made as follows: Melt 435 pounds of Banca tin in a babbitt kettle and throw on the surface, finely powdered soft coal. While the tin is melting place a clean crucible in the brass furnace and charge therein, 25 pounds of copper; when red hot, add ¼ pound soda ash, a little salt and several handfuls of charcoal. Permit the copper to melt and to become hot, then add 1¼ pounds of bright tin plate, in small strips. Do not drop in all the tin plate at once, as when it becomes hot it will ball and weld together and will, therefore, be in such a condition that it can only be melted with difficulty. Add the tin plate strips as gradually as possible, and stir between additions, so that all the iron is melted, and to insure this, it may be necessary to superheat the copper for a short time. Then add 6 ounces of sulphur, stir thoroughly, after which add 35 pounds of antimony, and when dissolved, withdraw the crucible and pour the contents into the melted tin, stirring as much as possible, meanwhile. In running the ingots, pour from one end, which will give a clear, smooth surface, and if the metal is poured rather hot, it will show the golden colors some makers admire. This alloy will be found to give a ringing sound when struck, and at the same time is very tough, and will give good service, providing lubrication is not neglected.

Aluminum for Marine Work

We have always understood that aluminum does not readily corrode and would like to have your idea as to whether it is as good as brass for marine work.

Aluminum cannot be compared with brass or bronze for such work, and is only used on account of its lightness, and while it may last indefinitely on the upper works of boats, where it is constantly kept bright by use, or occasional polishing, it is not a suitable metal to use where it is exposed to dampness or where it is periodically wet by water, as it is easily corroded under such conditions. This is especially the case when in contact with some other metals, such as copper, as galvanic action is then set up, which greatly hastens the corrosion of the aluminum. Salt water is more destructive to this metal than fresh water and rapidly corrodes and converts either aluminum or its alloys into a thick white slime of aluminum chloride. Therefore, it is not suitable for marine work when it will be in contact with sea water, and although great results were expected from it, in connection with the hulls of racing yachts, experience has not justified its application for such purposes, as its life is too short. Aluminum is a very delicate metal, as it is easily corroded by acids and alkalis.

Gun Metal

We have a number of castings to make of the standard gun metal alloy, copper, 88 per cent; tin, 10 per cent; zinc, 2 per cent. The specifications require a tensile strength of not less than 38,000 pounds per square inch, with an elongation of 10 per cent. We have experienced considerable trouble in meeting these requirements, although we have observed all possible precautions in melting to prevent oxidation, and we would like to know in what manner it is possible to improve the alloy, without materially altering the composition.

The only way in which the alloy can be improved is by the introduction of phosphorus, which can be added in several ways, but we advise the use of either phosphor-tin or phosphor-copper, and suggest the formula be changed as follows: Copper, 88 per cent; tin, 9.5 per cent; phosphor-tin, 0.5 per cent; zinc, 2 per cent. The phosphorus will deoxidize the alloy and greatly improves the tensile strength and elongation of all the alloys generally known as gun metals, and which usually contain zinc. If you find this alloy needs further improvement the phosphorus can be considerably increased.

Brass Bushings

I am making some brass bushings, averaging from 10 to 20 pounds in weight as well as crank boxes weighing about 105 pounds, and find that the brass eats into the sand and swells. I have tried flour and lime, but it does not give good results. The sand is such as is used for gray iron castings.

Bushings of the size mentioned should cause no trouble. It is better, however, to cast them horizontally than vertically; the mold should be firmly and evenly rammed and the sand should be the same as is used on the snap floors for iron. The molds for crank boxes can be coated with plumbago brushed on dry and then slicked the same as for iron. If they are not evenly rammed, the castings will swell and if poured too hot, the metal will eat into the sand. Therefore, ram the molds evenly and pour the metal cooler and you will experience no further trouble.

Cheap Alloys

We would like a formula for a cheap, fairly soft, easily tooled alloy for heavy brass castings, such as steam valves and other engine work.

Try the following for steam valves and work of similar character: Copper, 87 per cent; tin, 6 per cent; zinc, 5 per cent, and lead, 2 per cent. For bearings: Copper, 85 per cent; tin, 10 per cent and lead, 5 per cent. A cheaper alloy consists of copper, 74 per cent; zinc, 17 per cent; lead, 4 per cent and tin, 4 per cent.

Brass Couplings

We would like a formula for a red metal for couplings, that will machine easily and that can be stretched. We make them in both red and yellow brass, and it is only with the former that we have trouble.

Try the following alloy: Copper 87 per cent, zinc 8 per cent, tin 3 per cent, lead 2 per cent.

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The Foundry Trade in 1910

The last year, in retrospect, recorded a decline in consumption during the early summer months, which was further aggravated by depressed financial conditions. A slight improvement developed early in the fall, which was only of short duration, and from November to the end of the year, trade in all lines was quiet. Prices for castings early in the year were on a basis which netted the foundrymen a fair profit, but following the decline in pig iron values, quotations were reduced to lower levels, which in many instances barely represented the cost of production. The quiet condition of the foundry trade during the last half of the year was not, however, without its compensating features. The opportunity thus presented for introducing modern labor-saving devices was grasped by many foundrymen, and equipment manufacturers generally operated at capacity throughout the year. Sales of molding machines have exceeded the totals of any previous year in the history of the trade and the future foreshadows an even greater demand, as foundrymen, in all lines, are now endeavoring to replace hand-molding methods with machine operations. There has been a further development in jolt-ramming machines which is destined to eliminate a large amount of heavy floor work. Only recently one large concern successfully rammed a 66,000-pound mold on a machine of this type and it is predicted that the day of the jolting machine having a ramming capacity of 50 tons is not far distant. More machines are now available for making cores of irregular form and small sizes have been built for bench work. Yet, notwithstanding the progress in molding machine practice and the increasing use of this labor-saving device, a shortage of molders was reported in all sections of the country during the first half of the year. Foundrymen generally are displaying a greater interest in the proper preparation and economical use of molding, core and facing sands, and regardless of the proximity of foundries to molding sand pits, sand-preparing plants are being installed in all modern shops. For the brass foundryman many new types of furnaces have been introduced, and the practice of melting small heats of iron and steel in gas and fuel oil furnaces, particularly for automobile castings, is growing. There is also a reversal of sentiment in the foundry trade in favor of continuous operation and the most notable installation of this kind made during the year, described elsewhere in this issue, is intended for the production of cast iron pipe.

Trade Outlook

During the month of December there was little further improvement in the foundry trade, and preceding the holidays there was a decided slackening in the demand of all metals. Iron and steel works are operating at not much more than half capacity, and the foundry melt, in practically all branches of the trade, has been greatly curtailed. Yet, notwithstanding the depressed business conditions, the tonnage now produced by the foundries is greater than during either 1906 or 1907, which indicates the tremendous increase in consumption in recent years. The producing capacity has likewise been greatly extended and many shops that are today melting the same tonnage as they did several years ago report a curtailed output, but their molding and melting capacity has, in the meantime, been greatly increased. Aside from contracts for rail requirements the railroads have not indicated to what extent rolling stock purchases would be made in 1911, and as the car orders involve large tonnages of castings, the prosperity of the foundry trade will largely depend upon the action of these interests. Automobile manufacturers are more hopeful as to the future and are now engaged in building cars for the coming season. As a result of this increased activity, foundries making a specialty of brass and aluminum casting for the motor car industry are operating at capacity to meet immediate requirements. Malleable founders report no lack of orders from implement manufacturers, but the railroad tonnage in this, as well as the steel casting branch of the foundry trade, still continues light. Gray iron jobbing foundries in all sections of the country have curtailed operations. Pig iron prices remain practically unchanged and are as follows in the leading producing centers: No. 2 Philadelphia, $15.50; No. 2 local, Chicago, $16.00; No. 2 Cleveland, $14.25; No. 2 southern Birmingham, $11; Lake Superior charcoal, Chicago, $18. A comparison of pig iron quotations at the close of 1909 with the end of 1910, is presented herewith:

	1909.	1910.
No. 2 local, Chicago	$19.00	$16.00
No. 2 Philadelphia	19.00	15.50
No. 2 Cleveland	18.00	14.25
No. 2 Birmingham	14.50	11.00
Lake Superior charcoal, Chicago	19.50	18.00
Basic, Pittsburg	17.90	14.40

FOUNDRY and PATTERN SHOP EQUIPMENT

Melting furnace equipped for pouring metal direct into molds --- Sand blast tumbling barrel --- Flask bar tucker --- Air compressors --- Stripping plate and turn-over molding machines --- Sand mixing plant --- Core machine

IN THE accompanying illustrations are shown views of a metal melting furnace equipped with a tilting device which permits of pouring the metal direct from the furnace into the molds or chills, in place of first pouring it into a heated ladle or crucible from which the metal is subsequently cast into molds. The second handling of the metal is frequently objectionable, as it loses considerable heat when poured into crucibles or ladles, and for this reason must be raised to a temperature considerably higher than when poured direct into the molds without first transferring it into another vessel. When making light or intricate castings it is essential to pour the metal into molds or chills direct from the vessel in which it is melted, owing to the fact that it is liable to chill, and since the introduction of automatic and other types of molding machines, the pouring of the molds has been a serious problem which has frequently curtailed the output of these machines. By pouring direct, however, the casting of the molds will be greatly facilitated. Rotary or tilting furnaces, as ordinarily built, are mounted on trunnions in such a manner which permits of the rotation of the furnace body when pouring the metal. The pouring spout of the furnace describes an arc in proportion to the rotation of the furnace. On account of shifting movement of the pouring spout it is difficult to pour the metal direct into molds, as it is necessary to move the receptacle back and forth to catch the stream.

Realizing the economies that can be effected by a furnace from which the metal can be poured direct into the molds, the Rockwell Furnace Co., 26 Cortlandt street, New York City, has built a melting furnace, shown herewith, from which the metal can be poured direct. The metal can be melted with, or without crucibles, using oil or gas as fuel, and the furnace with its operating device is the invention of W. S. Quigley, vice president of this concern. This difficult pouring problem has been solved by mounting the furnace in such a way that it tilts or revolves around its pouring spout on an axis passing transversely through the spout, thereby permitting the metal to always flow from a fixed point. The tilting of the furnace in this way permits of pouring the entire contents into an opening less than 2½ inches in diameter and at any desired speed, which can be increased or decreased by the operator, who can instantly raise, lower or lock the furnace in any desired position.

The furnace shown in Fig. 2, which has the appearance of a melting medium of the tilting crucible type (the open flame furnace not being shown), but which is rotated in the same manner, is mounted on trunnions and may be revolved by hand for charging, mixing, skimming and for pouring the metal into a ladle or crucible in the regular manner, by the aid of the hand wheel at the side. This furnace, however, has an additional guide over each trunnion with stops, which in the position shown in this illustration, prevents the furnace from being tilted by hand further than the special bearings into which the guides are locked when ready to pour with the pouring device.

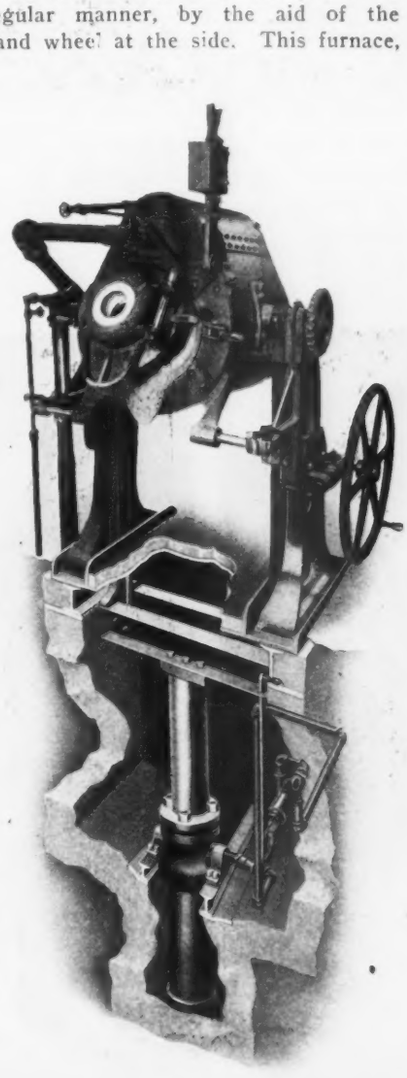


FIG. 1—METAL MELTING FURNACE, SHOWING HYDRAULIC RAM FOR TILTING

The lifting or rotating device, shown in Fig. 1, consists of a hydraulic ram, the speed of which, in either direction, is controlled by a hand lever shown in the foreground in Fig. 2. This lever operates a balanced valve, which regulates the flow of water in the lifting cylinder. A small hydraulic pump, shown in Fig. 5, driven by a 2-horsepower motor, operates the hydraulic ram. This power plant is sufficient to operate from three to five furnaces and the pump may be belt-driven from a line shaft if desired. The fuel, which may be oil or gas, is conveyed to the furnace through telescopic pipes, Fig. 1, which permit the furnace to be operated in any position. The switch and pressure controlling device, shown on the panel above the motor and pump, Fig. 5, automatically maintain a uniform pressure of between 80 and 100 pounds in the tanks in the background. The exhaust water or waste from the cylinder flows back to an open tank on which the reservoir rests and is used repeatedly, the only loss being from evaporation. To prevent freezing, a solution of 3 pounds of calcium chloride to each gallon of water will permit it to withstand a temperature of —10 degrees Fahr., but if preferred, oil may be substituted for the water. In Fig. 4 the furnace is shown in position ready to pour the metal and in Fig. 6 the metal is being cast into a mold for an engine driver bearing casting. Fig. 7 shows another pouring position, the furnace being nearly empty and is rotated practically half way.

As the metal is poured direct into the molds, to operate the furnace economically, the molds or chills are conveyed from the molding machine to the furnace and after being poured are carried away. This can be accomplished by placing the molds on low cars operating on tracks or by means of an endless belt or chain conveyor. When operating by this

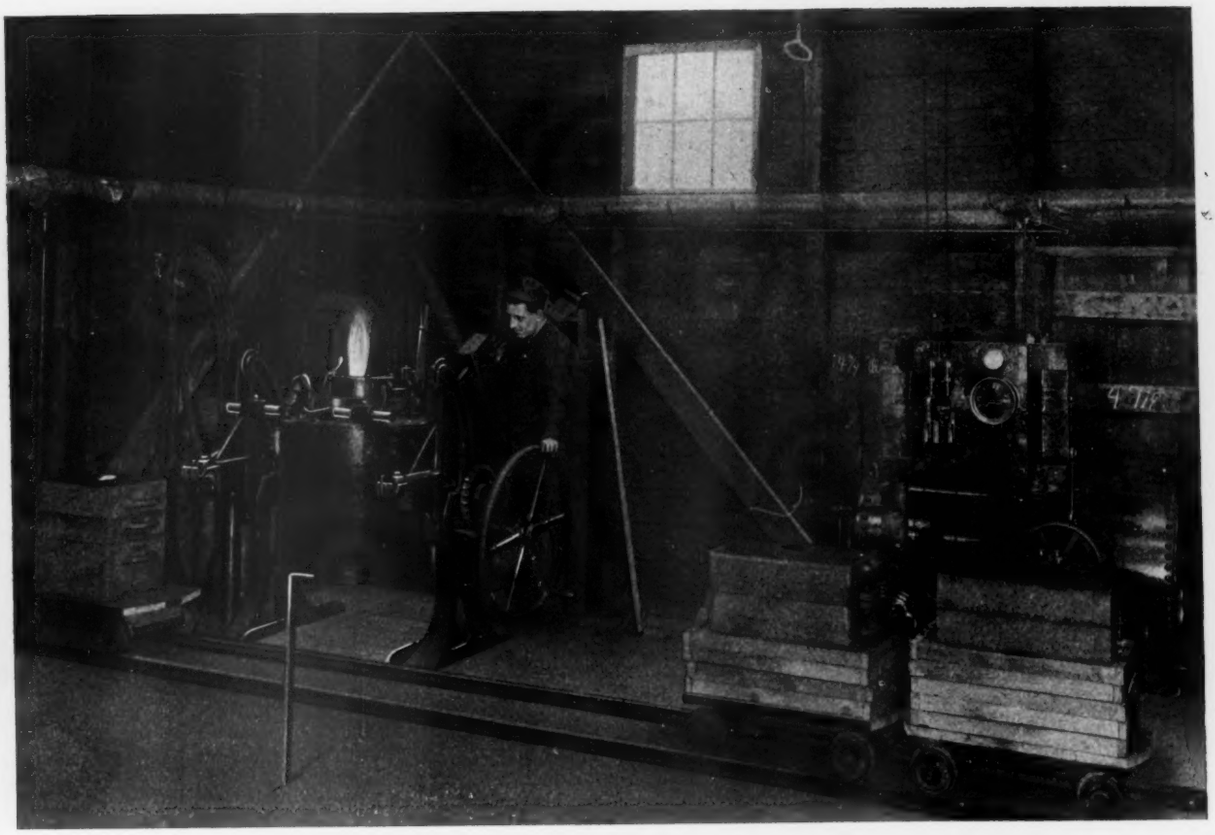


FIG. 2—THE FURNACE IN MELTING POSITION

method the molding machine operator places the molds or chills on the conveying device and as rapidly as the molds are made the flasks are carried away to the furnace to be cast. While still on the conveyor they are poured and are then delivered to the shaking-out floor. If the castings are of such a nature that they can be shaken-out within a few minutes after pouring, an automatic trip, operated by gravity, is

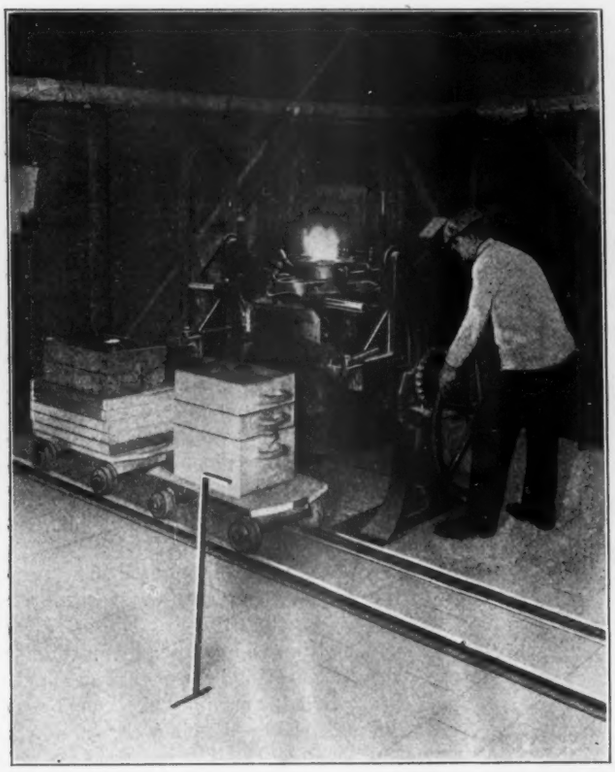


FIG. 3—PREPARING TO POUR THE METAL DIRECT FROM THE FURNACE INTO A MOLD

FIG. 4—THE FURNACE SLIGHTLY TILTED AT THE BEGINNING OF THE MOLD-POURING OPERATION

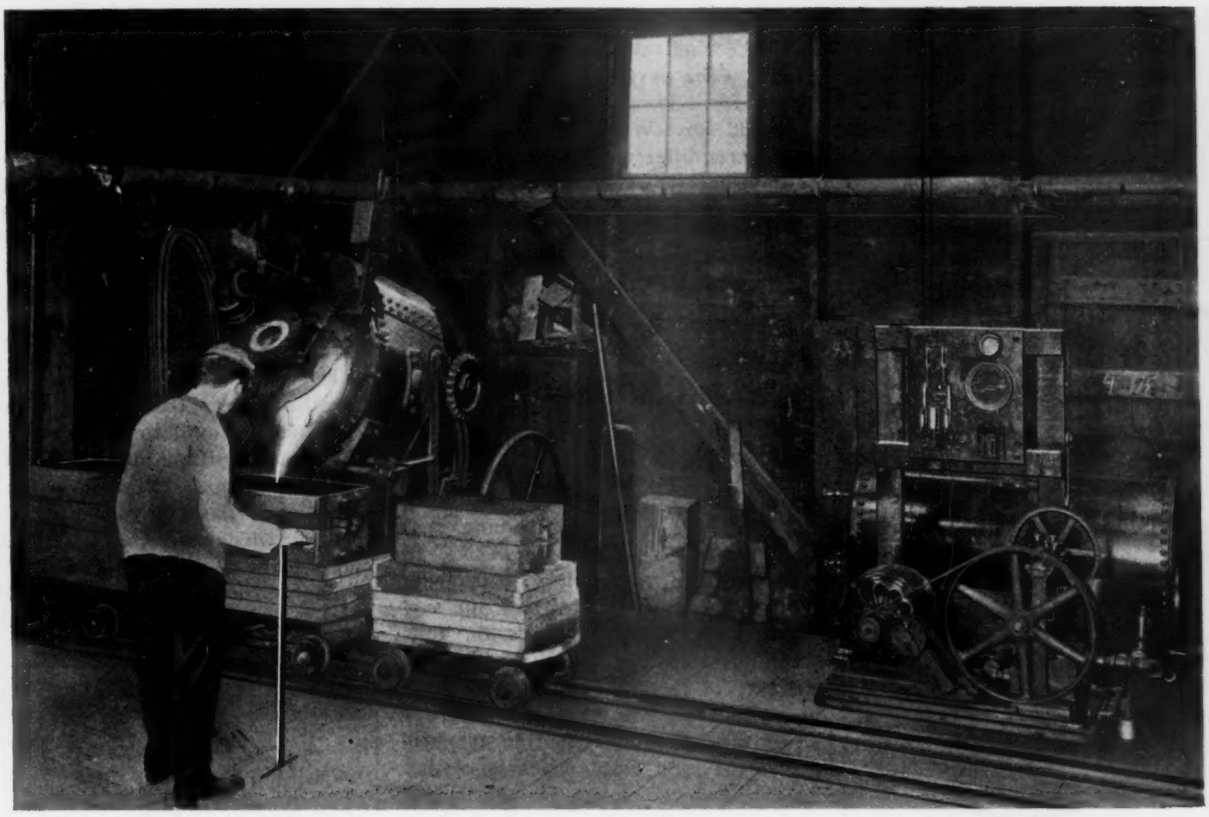


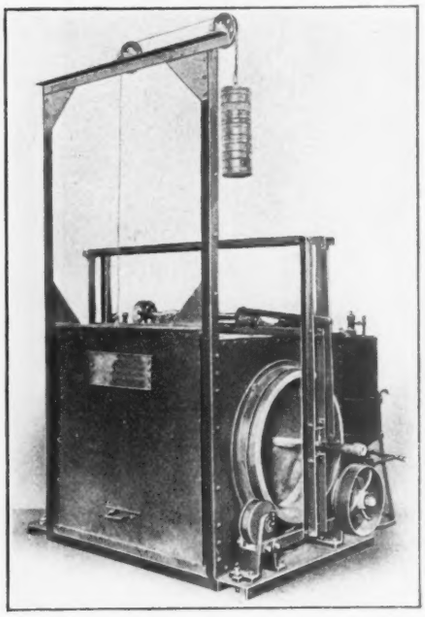
FIG. 5—MELTING FURNACE WITH HYDRAULIC POWER PLANT AT THE RIGHT. TRACKS FOR THE MOLD CARRIAGES ARE SHOWN IN THE FOREGROUND

provided, the flask falling onto a grating on the shaking-out floor. The sand passes through the grate, the castings are thrown into a dump bucket for delivery to the tumbling mills, and the flasks are placed on the conveyor and are carried back to the molding machine. The sand, as it passes through the grating, falls into

FIG. 6—POURING A MOLD; THE FURNACE IS SLIGHTLY TILTED

FIG. 7—FURNACE TILTED TO DRAIN OFF THE LAST OF THE METAL

the hopper of a sand mixing machine, where it is again prepared for use, or it falls into a dump bucket underneath the grating and is carried away to the point where the sand is tempered and again prepared for use. With the exception of the men em-



SAND BLAST TUMBLING BARREL

ployed for preparing the sand, the furnace can be operated, molds made and shaken-out, by only three men. A further advantage of this continuous system is the practical elimination of the molding floors, which have been gradually increased in size with the growing efficiency of the molding machine. If the nature of the castings is such that they must remain in the flasks for several hours or more before shaking-out, the poured flasks are automatically delivered to a storage floor where, by means of a quick-acting device, they are lowered from the conveyor to the storage floor and allowed to cool. When ready to be shaken-out they are raised by this device and transferred by the trolley onto the conveyor, which carries them to the shaking-out floor.

The application of this system to brass mill casting shops provides an economical equipment for melting and casting the metal. The molds are placed on racks, which, instead of being stationary, are on a carriage and operate on a track extending in front of the furnace. This will permit of casting the metal with the molds either in a vertical or slightly inclined position and will, furthermore, permit of the use of pouring strainers or the metal can be poured direct into the molds. Rack carriages can be arranged in a pit to accommodate the various lengths of molds, as well as for tube shell and bolt and wire bar molds. The easy manipulation of the molds for taking up the shrinkage is provided for. While operating conditions are different in every foundry, the furnaces, operating device, and conveyor can be adapted to the requirements of almost any plant, and it is claimed will effect great economies in the casting of the metal and the handling of the molds.

Sand Blast Tumbling Barrel

In the accompanying illustration is shown the Ohio sand blast tumbling barrel, designed for cleaning castings of small and medium size, in quantity, without injuring or defacing their sharp edges, angles and fine surfaces. The barrel operates on four trunnions and is slowly revolved at the rate of three revolutions per minute. The speed is ample and exposes all surfaces to be cleaned to the action of the sand blast, which is carried into the barrel through two horizontal pipes, terminating in nozzle holders provided with renewable jets, which are swung across the line of revolution of the barrel at a speed sufficient to cover all of the castings to be cleaned.

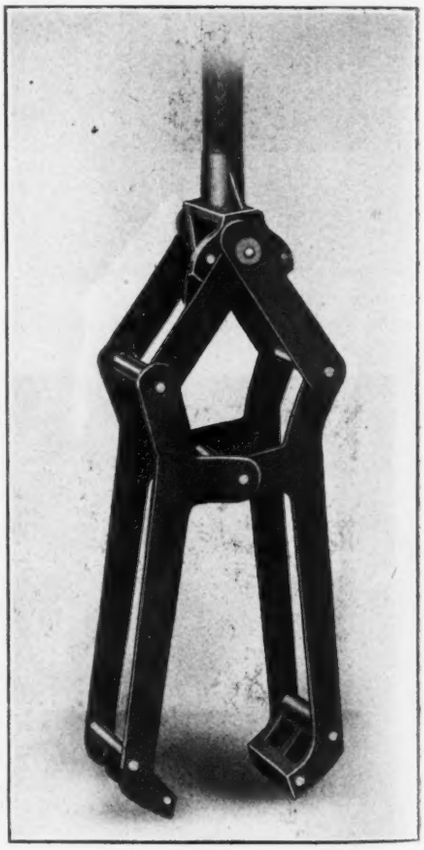
In designing this device, care was exercised to locate all bearings and trunnions outside of the housing, away from the dirt and sand. An effort was also made to insure the easy removal of all wearing parts and to mount the bearings and trunnions so that there could be no warping or spreading. The ends of the barrel are made of cast iron and to these are bolted steel staves, so spaced that the sand escapes through the openings between them, and which can be easily renewed at small cost, being made of standard merchant shapes. The four trunnions are provided with roller bearings to reduce friction and wear to the minimum. The nozzle holders are each connected to a Drucklieb injector sand blast, which is adjustable and carries nozzles of standard type, easily renewable when worn by the action of the sand. The nozzles are actuated by a connecting rod operated by the crank disc, which takes its power from the main driving shaft.

The housing of this device is of sheet steel, with an exhaust connection in the back, through which the dust is removed by an exhaust fan. With low air pressures, the cost of operating the tumbling barrel is exceedingly small, and with air pressures from 10 to 20 pounds, brass castings can be cleaned at the rate of 250 to 300 pounds in 10 minutes. Gray iron, crucible steel and other castings can be cleaned in 15 minutes with moderate air pressures.

These barrels are made in several sizes by J. M. Betton, 178 Washington street, New York City, and the J. D. Smith Foundry Supply Co., Cleveland, foundry engineers.

Flask Bar Tucker

The automatic flask bar tucker shown in the accompanying illustration, has been designed by James Whitehead, of the Abrams Cox Stove Co., Philadelphia. This device is intended to obviate the tucking of bars by hand, which is not only frequently inconvenient, but has proven an exceedingly irksome task to molders who are compelled to travel on their



FLASK BAR TUCKER

knees on boards placed across the bars of large flasks when tucking the sand. With the use of this flask bar tucker the molder can stand erect when tucking bars, and, in addition the work is facilitated. The tool operates automatically and consists of a wooden handle inserted in an iron socket and a gage is provided to maintain the vertical alignment of this device. To this casting are connected

the steel legs to which are fastened at its opposite end, small iron castings which do the work of tamping or tucking the sand under the flask bars. A small casting near the top of the flask bar tucker prevents the jaws from opening beyond the required distance. When the tool is raised the jaws open automatically and when brought down into the sand they close together, forcing the sand underneath the bar. In this way the sand can be tamped more uniformly around the bars than can be done by hand. The jaws contain two openings each, which obviate the packing of the sand at any point except where most desired, that is, against the bar where the sand is uniformly tamped by the faces of the jaws. A demonstration of this device was recently made at a meeting of the Philadelphia Foundrymen's Association.

Small Air Compressors for Heavy Duty

In Figs. 1 and 2 are shown single-stage, steam and power-driven air compressors, respectively, built by the Sullivan Machinery Co., Chicago. These compressors have been designed especially for the severe service required of this class of machines in foundries, machine shops and similar industrial plants.

These compressors range from small to moderate capacities and are built for various pressures from 10 to 100 pounds per square inch. They are provided with heavy, substantial

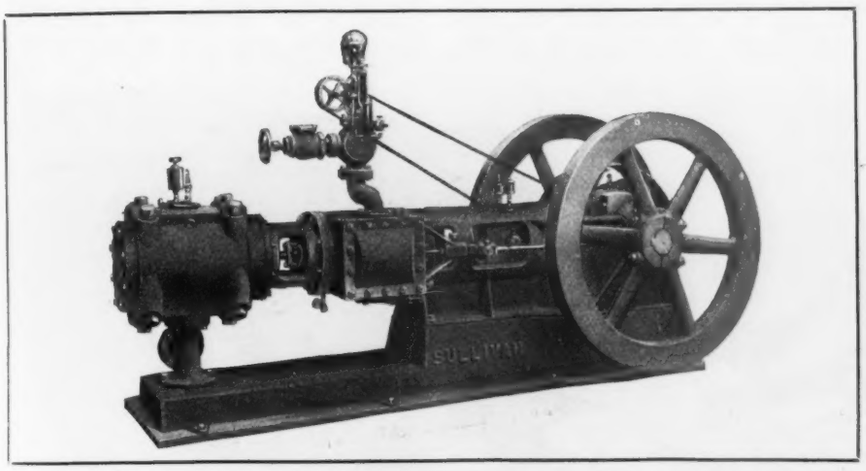


FIG. 1—SINGLE STAGE, STEAM-DRIVEN AIR COMPRESSOR

frames, supporting the bearings and crank shaft at one end, and the steam and air cylinders at the other. They are of the center crank type and a heavy steel guard surrounds the crank and prevents oil from being thrown upon the floor. In the steam-driven machines, the steam slide valve is controlled by an eccentric on a shaft, with which it is connected by a simple arrangement of valve rods. The air cylinder is placed outside the steam cylinder and is connected to it by a heavy distance piece. The air cylinder is supported on a sub-base, which extends the entire length of the compressor and maintains the proper alignment of all parts.

On the belt-driven machines, the air cylinder is attached directly to the rear end of the frame, and all working parts, such as the crank shaft, cross-head, connecting rods and main bearings, are designed to insure an ample factor of safety. All parts liable to wear are arranged so that readjustments may be easily made. The air cylinder is water-jacketed and the cylinder heads likewise are jacketed over their entire surface. The air valve mechanism consists of radial automatic poppet valves for both the inlet and discharge. These valves are placed close to the ends of the cylinder, the inlet valves being at the bottom and the discharge valves at the top of the cylinder. The valves act in a true radial direction to the axis of the cylinder and reduce the losses in efficiency made necessary by clearance. The ports, or pockets, leading to the valves are short and direct, so that practically no air is trapped after compression, instead of being expelled from the cylinder. The valves and their parts are so made that in case of breakage it is impossible for the broken parts to enter the bore of the cylinder. The valves are held in place in cages which seat by means of taper fits in the cylinder walls. To remove these valves, it is only necessary to unscrew the plug on the outside of the cylinder, when the entire valve and cage may be withdrawn for inspection or regrinding. The main bearings have adjustable caps and are heavily lined with babbitt metal. A box pattern cross-head is used, fitted with adjustable shoes.

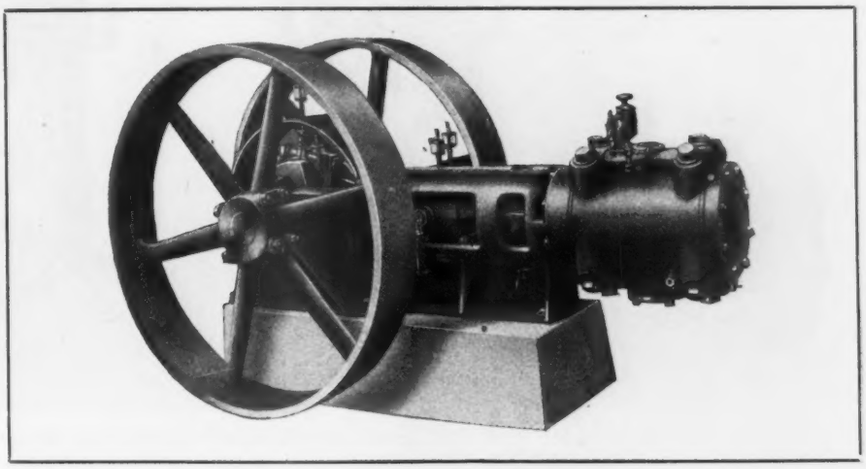


FIG. 2—BELT-DRIVEN AIR COMPRESSOR

The steam-driven air compressors are governed by a split-ball throttling regulator with an extra cylinder, which places the throttle valve under the influence of the air receiver pressure. Ordinarily, the governor varies the speed of the compressor to supply the demand for air, the halves of the ball, by their centrifugal action, preventing the compressor from exceeding a safe speed. The power-driven machine, Fig. 2, is fitted, when desired, with an unloading device placed on the air inlet of the compressor. This device is set to shut off the incoming air to the compressor when the receiver pressure exceeds a pre-determined point. This permits the compressor to operate at a regular speed by compressing no air until the receiver pressure again falls below the

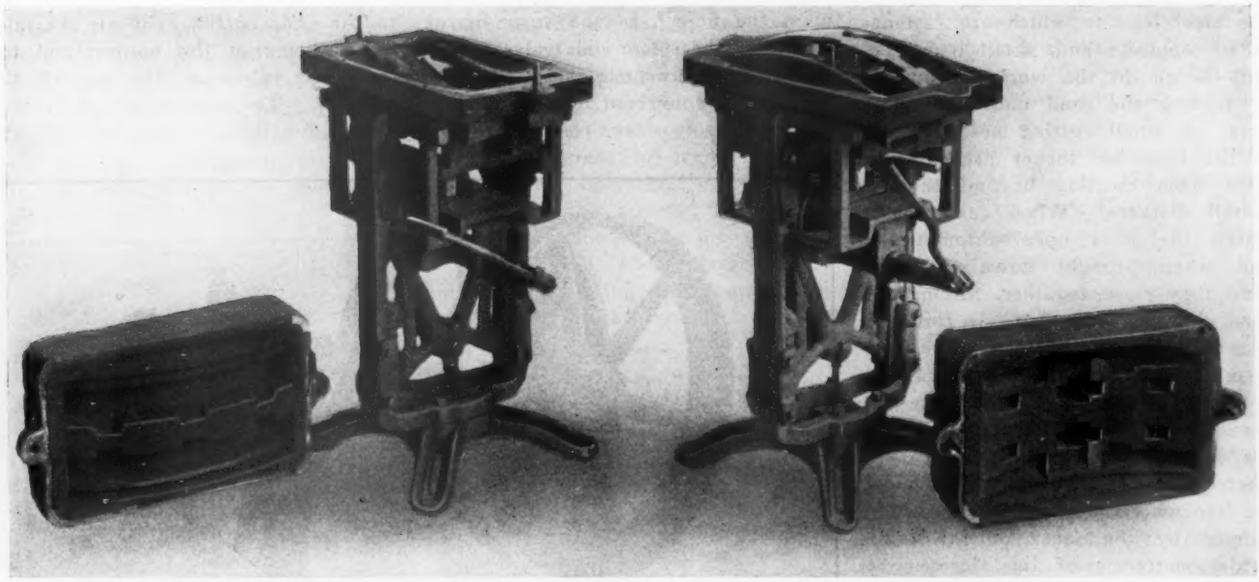


FIG. 1—STRIPPING PLATE MACHINES FITTED WITH PATTERNS FOR MOLDING STREET CAR BRAKE SHOES

point set. This effects economies in the amount of power used when the compressor is furnishing air intermittently. These machines are fitted with sight feed oil caps on important bearings, and the air cylinder machines, of similiar capacity, are also furnished for operation by electric motor, or a gasoline engine, as desired.

Stripping Plate and Turn-over Draw Molding Machines

In Figs. 1 to 4 are shown two types of molding machines of stripping plate and turn-over draw designs, respectively, manufactured by the Edward A. Pridmore Co., Chicago. A pair of stripping plate machines, fitted with patterns for molding street car brake shoes, is shown in Fig. 1. The yoke of this stripping plate, which carries the pattern, travels in one set each of upper and lower adjustable guideways. This insures an absolutely true pattern draw. The draw of the machine, which, at its maximum, is 5½ inches, can be instantly adjusted to the amount required for the pattern to be molded. This stripping plate type of machine is made in 14 different sizes, so constructed that each size is adjustable for use in a large variety of flasks. It is very low to facilitate ramming, is exceedingly substantial and rigid in construction, the upper and lower frames to which both sets of ways are attached being cast in one. The parting of the brake shoe pattern mounted on this pair of machines, is on the curve of the shoe. It is formed by building up parting pieces on one of the stripping plates and making corresponding recesses or depressions on the other plate. It is claimed that this method is more economical than making curved stripping plates to conform to the parting line of the pattern. The necessity of using a cut flask is also thereby obviated.

In Figs. 2, 3 and 4 is shown a molding machine of the turn-over draw type. In Fig. 4 the machine is shown fitted with the pattern ready to receive the flask. In Fig. 2 is shown the mold rammed with the bottom board and flask clamped to the pattern-carrying frame. In Fig. 3 the mold has been turned over onto the receiving device ready for the pattern to be drawn. These machines are made to be operated by hand or power, depending upon the size of the

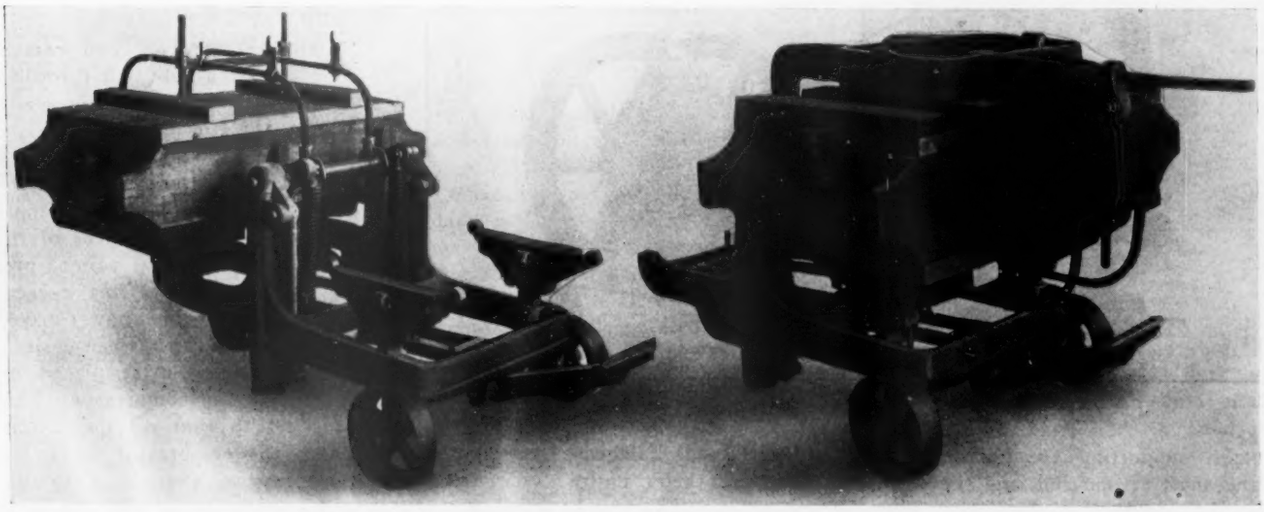


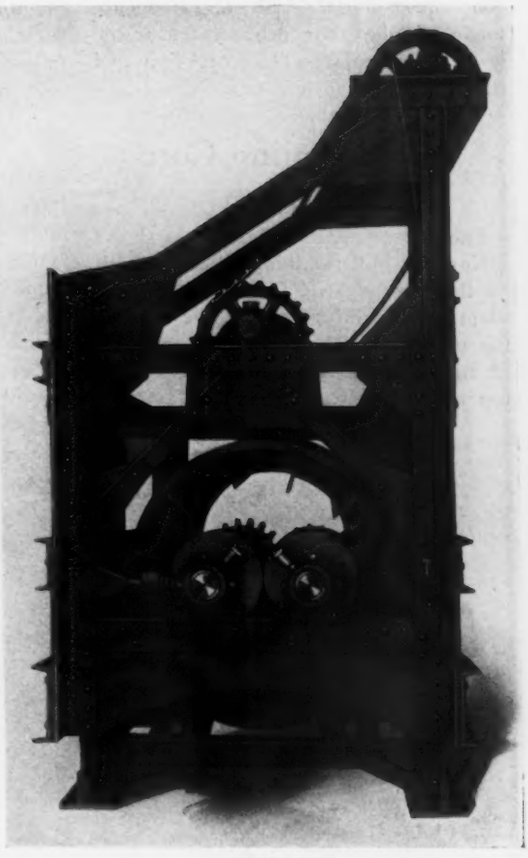
FIG. 2—TURN-OVER DRAW MACHINE, SHOWING THE MOLD CLAMPED WITH THE BOTTOM BOARD TO THE PATTERN FRAME

FIG. 3—MOLD TURNED OVER ONTO RECEIVING DEVICE, READY FOR THE PATTERN TO BE DRAWN

work to be molded. There is practically no limit to the amount of pattern draw which can be secured and stock sizes are made with draws of from 6 to 14 inches. The pattern-carrying frame operates on parallel uprights which are set and finished to such a degree of accuracy as to insure an absolutely true and even pattern draw. Adjustable counterbalancing devices operate automatically in conjunction with all working parts so that the heaviest mold can be turned over and the pattern withdrawn from the mold with the utmost facility. The flask receiving device is adjustable in every direction. The flask rods are fitted with adjusting screws so that flasks of various depths can be used on the same machine without "blocking up." All working parts are away from the sand and are carefully protected from dust. Several sizes of these machines have been designed especially for molding cores.

Sand Mixing and Blending Plant for Steel Foundries

A large sand-mixing and blending plant for preparing sand for steel foundries, having a capacity of 15 tons per hour, built by the Standard Sand & Machine Co., Cleveland, is shown in the accompanying illustration. This machine consists primarily of a steel drum made of rolled, ¼-inch plate, and is 48 inches in diameter and 76 inches long. To the interior of the drum and extending its entire length are attached 12 buckets which are riveted to the shell. The drum is slightly inclined toward the discharge end shown in this view, and the sand from the time of entering the drum to its discharge is carried up by the buckets and passed through the rollers 18 times in its travel from one end of the drum to the other. The sand, after being mixed, tempered and screened, is delivered to the drum by means of a spout. The two rolls inside of the drum are 72 inches long and 16 inches in diameter, which roll the sand, thus imparting to it additional strength. The complete plant consists of a proportioning machine, in which various grades of sand can be mixed or dry core compound can be added as desired. To accomplish this, feed hoppers are placed on the ground level from which the sand is conveyed, after being proportioned, by a bucket elevator to the spout of the machine, which delivers the sand to the drum. If screening is desired, a screen of any mesh can be provided, which will discharge foreign material at the side of the machine. For screening and tempering the sand, a continuous mixer is provided, fitted with a spraying pipe and water tank, which is equipped with a gage to regulate the amount of water used for tempering. A steam heater and an air pressure spraying device for applying liquid core compounds for preparing core mixtures can also be furnished with this machine if desired.



SAND MIXING AND BLENDING PLANT FOR STEEL FOUNDRIES

This plant accomplishes the mixing, tempering, screening, blending and rolling of old and new sands for core, facing and heap sands used in steel foundries. The rolling process does not break up the grains of sand and, on account of the thorough mixing and blending, a smaller amount of binder and facing material is required. The rolling of the sand after it has been screened, mixed and tempered insures uniformity, all of the grains receiving the same treatment. As a result of this a larger percentage of old sand can be used in the mixtures.

The drum revolves on trunnions, being driven by two gears which mesh with a gear extending around its circumference. The two rolls, through which the sand is passed, are tapered on the feed end and are corrugated to catch coarse material which may have passed through the screen, such as old cores, etc. One roll is fitted with springs which permit it to adjust itself to the quantity of material that is being passed through. One roll is also geared to revolve faster than the other, imparting a rubbing pressure to the material, making it smooth and porous. These machines are built in several sizes with capacities varying from 1 to 15 tons of sand per hour. The power required for operating the larger plants is approximately one horsepower per hour per

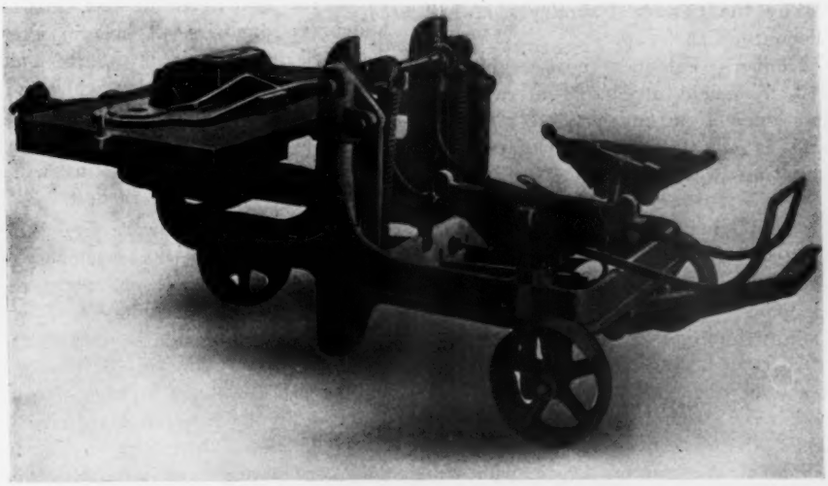
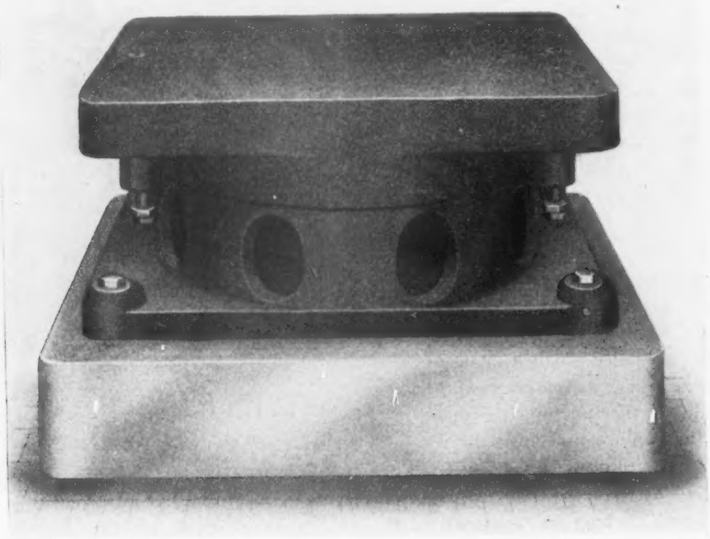


FIG. 4—TURN-OVER DRAW MACHINE FITTED WITH PATTERN READY TO RECEIVE THE FLASK

ton of material. All bearings are made of phosphor bronze, the frame is of structural steel construction and the gears are machine-cut.

Jolt-Ramming Core Machine

The accompanying illustration shows a Norcross jolt-ramming machine, built by the Arcade Mfg. Co., Freeport, Ill., adapted for making cores. The table of the machine is 24 x 30 inches and it is 15 inches high from the base to the top of the table. When installing the machine the foundation should be of sufficient height to bring the surface of the table on a level with the coremaker's bench. This permits sliding the core boxes onto the table where they are rammed. For ramming cores a stroke of only ½ inch is required. A concrete foundation is provided and the machine has a lifting capacity of 1,000 pounds.



JOLT-RAMMING CORE MACHINE

Shot in Cast Iron

Thomas D. West, 10511 Pasadena avenue, Cleveland, who is soliciting specimen castings containing globules in gas cavities, solidly encased shot iron, hard streaks or spots and white iron inside of gray or soft iron, announces that he will receive such specimens to March 1, instead of Jan. 1, as at first intended. A paper on this subject will then be prepared for presentation at the Pittsburg meeting of the American Foundrymen's Association. Mr. West is desirous of securing all the specimens he possibly can and the firms or individuals forwarding castings exhibiting these phenomena will not necessarily have their names mentioned in the paper, unless desired.

Paxson Exhibit

During the holiday week the J. W. Paxson Co., Philadelphia, held an exhibit of foundry supplies and equipment, which was attended by a large number of foundrymen of Philadelphia and vicinity. Foundry supplies and equipment were attractively displayed in the company's showroom and many new devices were also shown. During the past five years it has been the custom of this concern to hold similar exhibits, which have always been well attended.

Personal

B. W. Pherris has been appointed superintendent of the foundry operated by the Canada Foundry Co., Ltd., Toronto, Can.

Kenneth Falconer, cost accountant, 112 Mansfield street, Montreal, Can., has opened an office at this address and is now engaged in expert accounting work.

J. G. Bower has been appointed assistant manager of sales for the western district, of the Pressed Steel Car Co. and the Western Steel Car & Foundry Co., with offices in the Old Colony building, Chicago.

Allerton L. Cushman, after nearly 10 years in the government service, has withdrawn from this work and has established the Institute of Industrial Research at Washington, D. C., with temporary offices at 804 Hibbs building. It will be the object of the institute to undertake the investigation of industrial problems in all lines.

The Jonathan Bartley Crucible Co., Trenton, N. J., manufacturer of graphite crucibles, retorts, stoppers, nozzles, etc., announces that after Jan. 1, H. D. Cole will have charge of the company's business throughout the New England territory. Mr. Cole has had a wide experience in the manufacture of graphite crucibles and is thoroughly familiar, not only with their manufacture, but with their use. Mr. Cole will probably locate permanently in one of the New England cities, which will afford him an opportunity of keeping in constant touch with the trade.

Trade Notes

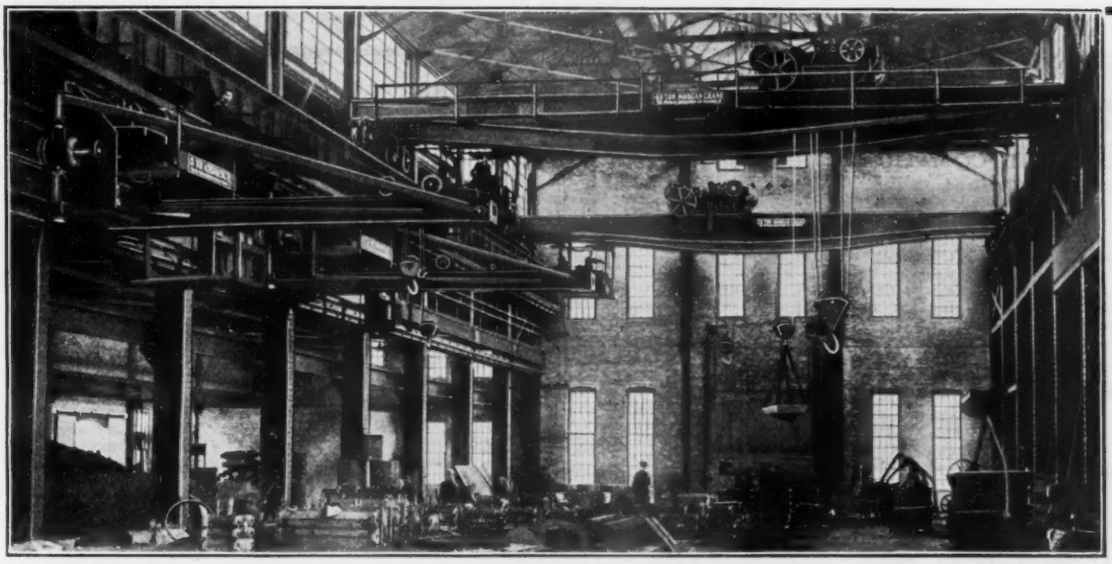
R. B. Seidel & Co., crucible manufacturers, Philadelphia, have added two new buildings, 60 x 14 feet and 23 feet square, respectively, as well as a kiln, which will nearly double the output of this plant.

The H. W. Johns-Manville Co., New York City, announces the removal of its offices, formerly located at 85 Shelden street, Houghton, Mich., to more commodious quarters at 96 Shelden street. As in the past, S. T. Harris, who has been associated with this concern for a number of years, will be in charge of this branch.

The Lewis Institute, Chicago, in an announcement recently issued, gives the attendance during the present quarter as the largest in the history of this school. The registration totaled 2,700, including both day and evening students. In the evening classes there are 1,100 men registered and 550 men and boys are in attendance in the day school.

The Hawley Down Draft Furnace Co., Chicago, is issuing a monthly bulletin describing its various lines of melting furnaces for use in iron, steel, malleable and brass foundries. A bulletin recently published describes the method of making steel castings in a Hawley-Schwartz furnace and a formula is included giving the requisite amount of scrap and pig iron required. These bulletins will be mailed to the trade on request.

The Vonnegut Hardware Co., Indianapolis, will conduct its machinery department after Jan. 1, under the name of the Vonnegut Machinery Co., which will be a branch of the Vonnegut Hardware Co. The Vonnegut Machinery Co. will be located in the building formerly occupied by the Francke Hardware Co., 43 to 45 South Meridian street. The sales organization will include Anton Vonnegut, Charles Rassman and C. B. Williamson.



Interior view of Foundry of the Indiana Steel Co., Gary, showing one Morgan 40-ton 4-Motor Crane and one Morgan 25-ton 4-Motor Crane, also two Morgan 5-ton Wall Cranes.

ENGINEERS AND MANUFACTURERS.

Pioneer Crane Builders. 3300 Cranes in Successful Operation.
Builders of Hammers, Shears and all kinds of heavy special machinery.

CHICAGO, ILL.
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The MORGAN ENGINEERING COMPANY
ESTABLISHED 1868
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PITTSBURG, PA.
Frick Building
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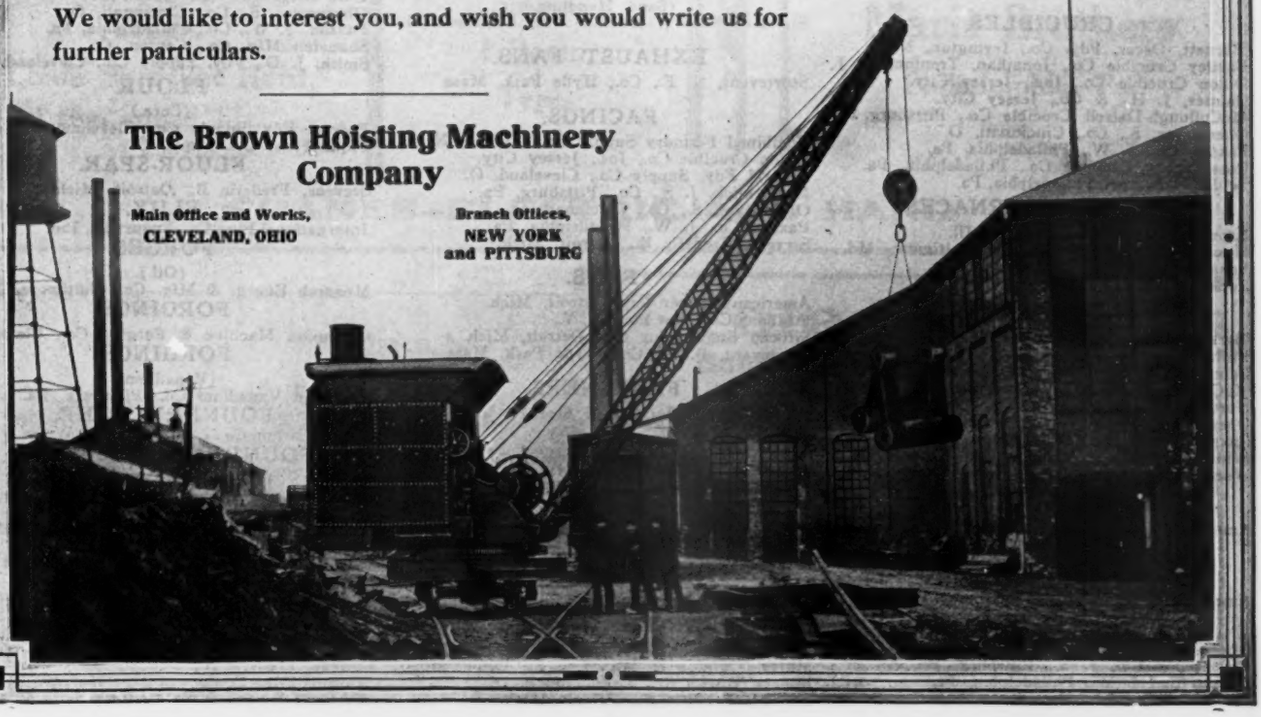
"Brownhoist" Locomotive Cranes

Foundries who are using our LOCOMOTIVE CRANES say they cannot dispense with them, and that they are the most useful equipments around their plants. We would like to interest you, and wish you would write us for further particulars.

The Brown Hoisting Machinery Company

Main Office and Works,
CLEVELAND, OHIO

Branch Offices,
NEW YORK
and PITTSBURG



CORE OIL.

National Core Oil Co., Buffalo, N. Y.
Paxson, J. W., Co., Philadelphia, Pa.
Peterson Co., T. J. Chicago, Ill.
Stevens, Frederic B., Detroit, Mich.
Whitehead Bros. Co.,
Providence, New York, and Buffalo.

CORE OIL COMPOUND.

Osborn Mfg. Co., Cleveland, O.
Paxson Co., J. W., Philadelphia, Pa.

CORE OVENS.

Falls Rivet & Mach. Co., Cuyahoga Falls, O.
McCormick Co., J. S., Pittsburg, Pa.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Millett Core Oven Co., Springfield, Mass.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Rockwell Furnace Co., New York.
Smith, J. D., Foundry Supply Co., Cleveland, O.
Whiting Fdy. Equipment Co., Harvey, Ill.

CORE.

(Tapering Machines.)
Brown Specialty-Machinery Co., Chicago, Ill.
Pangborn Company, Thomas W., New York.

CORE WASH.

Federal Fdy. Supply Co., Cleveland, O.
Stevens, Frederic B., Detroit, Mich.

CORRESPONDENCE SCHOOLS.

Milwaukee Correspondence Schools, Milwaukee.
Modern Systems Correspondence School,
Boston, Mass.

COUPLINGS.

(Air Hose.)
Cleveland Pneumatic Tool Co., Cleveland, O.

CRANES.

Brown Hoisting Machine Co., Cleveland, O.
Calumet Engineering Works, Harvey, Ill.
Cleveland Crane & Engrg. Co., Wickliffe, O.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Maris Bros., Philadelphia, Pa.
Morgan Engineering Co., Alliance, O.
Northern Engineering Works, Detroit, Mich.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Ridgway, Craig & Son, Coatesville, Pa.
Sellers, Wm., & Co., Inc., Philadelphia, Pa.
Shepard Electric Crane & Hoist Co.,
Montour Falls, N. Y.
Smith, J. D., Fdy. Supply Co., Cleveland, O.
Toledo Bridge & Crane Co., Toledo, O.
Whiting Fdy. & Equipment Co., Harvey, Ill.
Wonham, Sanger & Bates, New York City.

CRANES.

(Hand Traveling.)
Calumet Engineering Works, Harvey, Ill.
Northern Engineering Works, Detroit, Mich.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Toledo Bridge & Crane Co., Toledo, O.
Whiting Fdy. Equipment Co., Harvey, Ill.

CRUCIBLES.

Barnett, Oscar, Fdy. Co., Irvington, N. J.
Bartley Crucible Co., Jonathan, Trenton, N. J.
Dixon Crucible Co., Inc., Jersey City.
Gautier, J. H., & Co., Jersey City.
McCullough-Dalzell Crucible Co., Pittsburg, Pa.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Ross-Tacony Crucible Co., Philadelphia, Pa.
Seidel, R. B., Inc., Philadelphia, Pa.

CRUCIBLE FURNACES.

Kroeschell Bros. Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Paxson Co., J. W., Philadelphia, Pa.
Rockwell Furnace Co., New York.

CUPOLAS.

Barry & Zecher Co., Lancaster, Pa.
Buffalo Forge Co., Buffalo, N. Y.
Calumet Engineering Works, Harvey, Ill.
McCormick, J. S., Co., Pittsburg, Pa.
Northern Engineering Works, Detroit, Mich.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Whiting Fdy. & Equipment Co., Harvey, Ill.
Wonham, Sanger & Bates, New York City.

CUPRO-VANADIUM.

American Vanadium Co., Pittsburg, Pa.

CYLINDERS.

(Vanadium.)
American Vanadium Co., Pittsburg, Pa.

DOWEL PINS.

Obermayer, S., Co., Cincinnati, O.
McCormick Co., J. S., Pittsburg, Pa.
Paxson Co., J. W., Philadelphia, Pa.
Shanafelt Mfg. Co., Canton, O.

DRILLS.

(Pneumatic.)
Ingersoll-Rand Co., New York, N. Y.

DUST COLLECTORS.

Cleveland Blow Pipe & Mfg. Co., Cleveland, O.
Knickerbocker Co., Jackson, Mich.

DYNAMOS.

(Plating.)
Levett Mfg. Co., Matawan, N. J.

ELECTRIC GENERATING SETS.

Sturtevant, B. F., Co., Hyde Park, Mass.

ELEVATORS.

Curtis & Co. Mfg. Co., St. Louis, Mo.
Northern Engineering Works, Detroit, Mich.
Ridgway, Craig, & Son, Coatesville, Pa.
Union Elevator & Machine Co., Chicago, Ill.

ELEVATORS.

(Electric.)
Northern Engineering Works, Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.

ELEVATORS.

(Pneumatic.)
Northern Engineering Works, Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.

EMERY GRINDERS.

Osborn Mfg. Co., Cleveland, O.
Smith, J. D., Fdy. Supply Co., Cleveland, O.

ENGINES.

(Hoist, Automatic.)
Otis Elevator Co., New York City.

ENGINES.

(Steam.)
American Blower Co., Detroit, Mich.
Sturtevant, B. F., Co., Hyde Park, Mass.

ENGINEERS.

(Foundry, Mech., Elec., Etc.)
Gulick-Henderson & Co., Pittsburg, Pa.
Hawkins, David S., 1021 Rose bldg, Cleveland.
Northern Engineering Works, Detroit, Mich.
Pangborn Company, Thomas W., New York.
Seaver, John W., Cleveland, O.
Smith Foundry Supply Co., J. D., Cleveland, O.
Standard Sand & Machine Co., Cleveland, O.
Wonham, Sanger & Bates, New York City.

EQUIPMENT.

(Factory.)
Mfg. Equipment & Eng'r'g Co., Boston, Mass.

EQUIPMENT.

(Hoisting.)
Otis Elevator Co., New York City.

EQUIPMENT.

(Metal Shop.)
Mfg. Equipment & Eng'r'g Co., Boston, Mass.

EQUIPMENT.

(Sand Handling.)
Standard Sand & Machine Co., Cleveland, O.

EXHAUST FANS.

Sturtevant, B. F., Co., Hyde Park, Mass.

FACINGS.

Combined Foundry Supply Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City.
Federal Fdy. Supply Co., Cleveland, O.
McCormick, J. S., Co., Pittsburg, Pa.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Stevens, Frederic B., Detroit, Mich.

FANS.

American Blower Co., Detroit, Mich.
Anthony Co., New York, N. Y.
Sirocco Engineering Co., Detroit, Mich.
Sturtevant, B. F., Co., Hyde Park, Mass.

FASTENERS.

(Corrugated Steel.)
Shanafelt Mfg. Co., Canton, O.

FERRO-ALLOYS.

American Vanadium Co., Pittsburg, Pa.
Blackwell, G., Sons & Co., Ltd., Liverpool, Eng.
Midvale Mining & Mfg. Co., St. Louis, Mo.
Primos Chemical Co., Primos, Pa.

FERRO-COMPOUND.

Johns-Manville, H. W., Co., New York, N. Y.

FERRO-MANGANESE.

Metal Mfg. Co., Philadelphia, Pa.
Midvale Mining & Mfg. Co., St. Louis, Mo.
Rogers, Brown & Co., Cincinnati, O.
Stevens, Frederic B., Detroit, Mich.

FERRO-METALS.

Midvale Mining & Mfg. Co., St. Louis, Mo.

FERRO-SILICON.

Metal Mfg. Co., Philadelphia, Pa.
Midvale Mining & Mfg. Co., St. Louis, Mo.
Primos Chemical Co., Primos, Pa.
Roessler & Hasslacher Chemical Co., New York.

FERRO-VANADIUM.

American Vanadium Co., Pittsburg, Pa.
Primos Chemical Co., Primos, Pa.

FILLERS.

(Metallic.)
Clark Cast Steel Cement Co., Shelton, Conn.
Shanafelt Mfg. Co., Canton, O.
Shelton Metallic Filler Co., Derby, Conn.
Smooth-On Mfg. Co., Jersey City, N. J.

FILLETS.

(Leather and Wood.)
Cleveland Fillet Co., The, Cleveland, O.
McCormick Co., J. S., Pittsburg, Pa.
Obermayer, S., Co., Cincinnati, O.
Shanafelt Mfg. Co., Canton, O.

FIRE BRICK.

Combined Fdy. Supply Co., Buffalo, N. Y.
Gautier, J. H., & Co., Jersey City.
Harbison-Walker Refractories Co., Pittsburg, Pa.
Maurer, Henry, & Son, New York City.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Valentine, M. D., & Bro., Co., Woodbridge, N. J.
Wonham, Sanger & Bates, New York City.

FIRE CLAY.

Gautier & Co., J. H., Jersey City, N. J.
Harbison-Walker Refractories Co., Pittsburg, Pa.
Paxson Co., J. W., Philadephia, Pa.
Whitehead Bros. Co.,
Providence, New York, Buffalo.

FIRE SAND.

Paxson Co., J. W., Philadelphia, Pa.
Whitehead Bros. Co.,
Providence, New York, Buffalo.

FLASKS.

Adams Co., Dubuque, Iowa.
Baldwin, Tuthill & Bolton, Grand Rapids, Mich.
Barnett, Oscar, Fdy. Co., Irvington, N. J.
Brass Founders' Supply Co., Newark, N. J.
Killing Molding Machine Co., Davenport, Ia.
McCormick Co., J. S., Pittsburg, Pa.
Shanafelt Mfg. Co., Canton, O.
Sterling Wheelbarrow Co., Milwaukee, Wis.
Stevens, Frederic B., Detroit, Mich.

FLASKS.

(Iron.)
Turner Machine Co., Philadelphia, Pa.

FLASKS.

(Snap.)
Adams Co., Dubuque, Iowa.
Brass Founders' Supply Co., Newark, N. J.
Killing Molding Machine Co., Davenport, Ia.
Linn Mfg. Co., Springfield, O.
Obermayer, S., Co., Cincinnati, O.
Paxson, J. W., Co., Philadelphia, Pa.
Shanafelt Mfg. Co., Canton, O.
Smith, J. D., Fdy. Supply Co., Cleveland, O.

FLOUR.

(Core.)
Federal Fdy. Supply Co., Cleveland, O.
Piqua Flour Co., Piqua, O.

FLUOR-SPAR.

Stevens, Frederic B., Detroit, Mich.

FLUX.

International Flux Co., Evansville, Ind.

FORGES.

(Oil.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.

FORGINGS.

Champion Machine & Forging Co., Cleveland.

FORGINGS.

(Vanadium.)
American Vanadium Co., Pittsburg, Pa.

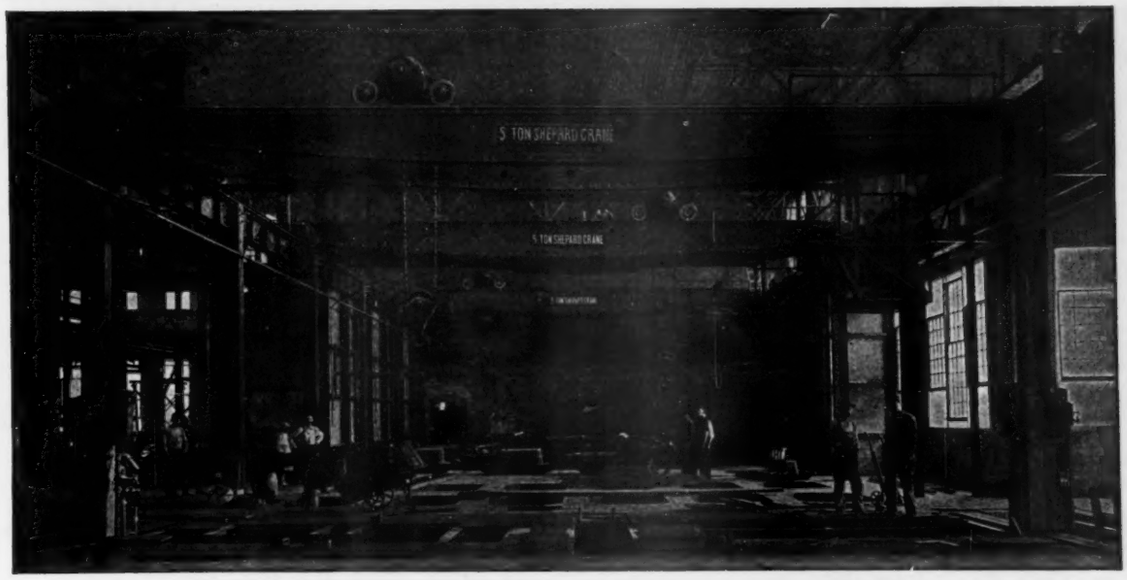
FOUNDRY COKE.

Mount Carbon Co., Ltd., Powellton, W. Va.

FOUNDRY EQUIPMENT.

(Iron and Brass.)
Barnett, Oscar, Fdy. Co., Irvington, N. J.
McCormick Co., J. S., Pittsburg, Pa.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Nicholls, Wm. H., New York City.
Northern Engineering Works, Detroit, Mich.
Obermayer, S., Co., Cincinnati, O.
Pangborn Company, Thomas W., New York.
Paxson Co., J. W., Philadelphia, Pa.
Sly, W. W., Mfg. Co., Cleveland, O.
Standard Sand & Machine Co., Cleveland, O.
Stevens, Frederic B., Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.
Wonham, Sanger & Bates, New York City.

For Foundry Service, or any other---Shepard Cranes!



Shepard Electric Crane & Hoist Co.

General Offices and Works, MONTOUR FALLS, N. Y.

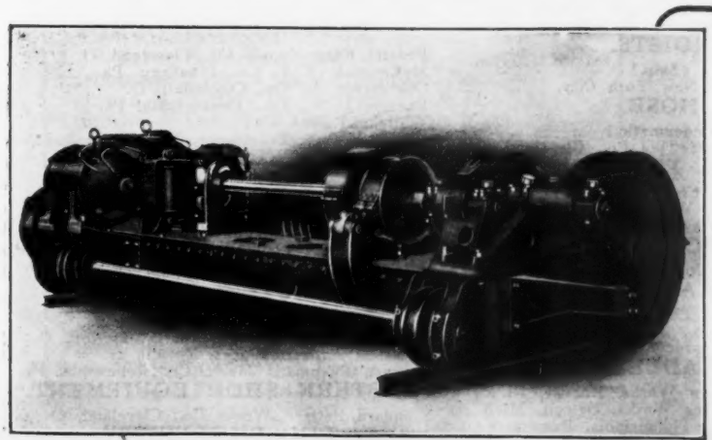
NEW YORK PHILADELPHIA PITTSBURGH SAN FRANCISCO CHICAGO MONTREAL

Hand Power Traveling Crane.
Chain Sprocket Hoist, two speed lift.

Single I Beam Type.

Maris Brothers
Philadelphia, Pa.

CRANES—ELECTRIC AND HAND



Toledo Cranes

Hand and Electric for any Service and Steel Structures

Experienced Engineers, Old and Tried Crane Design, Admitted the Best by People Who Know

The Toledo Bridge & Crane Co.

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TOLEDO, OHIO

M. A. BECK, Consulting Engineer
C. H. TUCKER, Chief Engineer

SALES AGENTS:
M. A. Beck, Milwaukee, Wis.
C. E. Stamp & CO., Cleveland, Ohio
The Cincinnati Iron & Steel Co., Cincinnati, Ohio
The Fairbanks Co., Philadelphia, Pa.

FOUNDRY SUPPLIES.

Combined Foundry Supply Co., Buffalo, N. Y.
Federal Fdy. Supply Co., Cleveland, O.
McCormick, J. S., Co., Pittsburg, Pa.
Kelly, T. P., & Co., New York, Chicago, Hamilton.
Metal Mfg. Co., Philadelphia, Pa
Obermayer, S., Co., Cincinnati, O.
Osborn Mfg. Co., Cleveland, O.
Pangborn Company, Thomas W., New York.
Paxson, J. W., Co., Philadelphia, Pa.
Shanafelt Mfg. Co., Canton, O.
Smith, J. D., Foundry Supply Co., Cleveland.
Standard Sand & Machine Co., Cleveland, O.
Stevens, Frederic B., Detroit, Mich.
Whitehead Bros. Co.,
Providence, New York, Buffalo.

FUEL BURNING APPLIANCES.

(Oil.)
Hauck Mfg. Co., Brooklyn, N. Y.

FURNACES.

Anthony Co., New York, N. Y.
Best, W. N., New York.
Bernz, Otto, Newark, N. J. (For painters, plumbers, etc.).
Caygill, J., Meadville, Pa.
Hawley Down Draft Furnace Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Rockwell, W. S. Co., New York, N. Y.
Smith, J. D., Fdy. Supply Co., Cleveland, O.
Wise, J. B., Watertown, N. Y.

FURNACES.

(Annealing.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Rockwell Furnace Co., New York.

FURNACES.

(Brass.)
Hawley Down Draft Furnace Co., Chicago, Ill.
Kroeschell Bros. Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Paxson Co., J. W., Philadelphia, Pa.
Rockwell Furnace Co., New York.
Whiting Fdy. Equipment Co., Harvey, Ill.
Wise, J. B., Watertown, N. Y.
Wonham, Sanger & Bates, New York City.

FURNACES.

(Case Hardening.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.

FURNACES.

(Crucible Steel.)
Hawley Down Draft Furnace Co., Chicago, Ill.
Whiting Fdy. Equipment Co., Harvey, Ill.

FURNACES.

(Galvanizing.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.

FURNACES.

(Heating.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Rockwell Furnace Co., New York.

FURNACES.

(Malleable Iron.)
Whiting Fdy. Equipment Co., Harvey, Ill.

FURNACES.

(Melting.)
Barnett, Oscar, Foundry Co., Newark, N. J.
Brass Founders' Supply Co., Newark, N. J.
Hawley Down Draft Furnace Co., Chicago, Ill.
Kroeschell Bros. Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Northern Engineering Works, Detroit, Mich.
Obermayer, S., Co., Cincinnati, O.
Paxson, J. W., Co., Philadelphia.
Rockwell Furnace Co., New York.
Rockwell, W. S. Co., New York, N. Y.
Wise, J. B., Watertown, N. Y.

FURNACES.

(Oil.)
Hauck Mfg. Co., Brooklyn, N. Y.
Hawley Down Draft Furnace Co., Chicago, Ill.
Kroeschell Bros. Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Rockwell Furnace Co., New York.

FURNACES.

(Open Hearth Steel.)
Whiting Fdy. Equipment Co., Harvey, Ill.

FURNACES.

(Reverberatory.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.

FURNACES.

(Soft Metal Melting.)
Kroeschell Bros. Co., Chicago, Ill.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Wise, J. B., Watertown, N. Y.

FURNACES.

(Tilting.)
Kroeschell Bros. Co., Chicago, Ill.
Wise, J. B., Watertown, N. Y.

FURNACES.

(Tinning.)
Monarch Engrg. & Mfg. Co., Baltimore, Md.

GAGGERS.

(Foundry.)
Franklyn Core Rod & Gagger Co., Franklyn, Pa.

GLUE.

Masek, C., Glue Co., Cleveland, O.

GOVERNORS.

(Float, Switches and Pressure.)
General Electric Co., Schnectady, N. Y.

GRAPHITE.

Dixon Crucible Co., Jos., Jersey City, N. J.
Federal Fdry. Supply Co., Cleveland, O.
Obermayer, S., Co., Cincinnati, O.
Paxson Co., J. W., Philadelphia, Pa.
Pettinos Bros., Bethlehem, Pa.

GRINDERS.

(Pneumatic, Portable.)
Cleveland Pneumatic Tool Co., Cleveland, O.

GRINDING MACHINERY.

Adams Co., Dubuque, Iowa.
Crescent Machine Co., Leetonia, O.

GRINDING TOOLS.

Stow Mfg. Co., Binghamton, N. Y.

HAMMERS.

(Pneumatic.)
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.

HEATERS.

(Feed Water.)
Hawley Down Draft Furnace Co., Chicago, Ill.

HEATERS.

(Ladle.)
Hawley Down Draft Furnace Co., Chicago.

HEATING AND VENTILATING APPARATUS.

American Blower Co., Detroit, Mich.
Sirocco Engineering Co., Detroit, Mich.
Sturtevant, B. F., Co., Hyde Park, Mass.

HOISTS.

Brown Hoisting Mach. Co., Cleveland, O.
Northern Engineering Works, Detroit, Mich.
Ridgway & Sons Co., Coatesville, Pa.
Sellers, Wm., & Co., Inc., Philadelphia, Pa.
Shepard Electric Crane & Hoist Co.,
Montour Falls, N. Y.
Whiting Fdy. Equipment Co., Harvey, Ill.
Yale & Towne Mfg. Co., New York.

HOISTS.

(Air.)
Calumet Engineering Works, Harvey, Ill.
Ingersoll-Rand Co., New York, N. Y.

HOISTS.

(Chain.)
Whiting Fdy. Equipment Co., Harvey, Ill.
Yale & Towne Mfg. Co., New York City.

HOISTS.

(Electric.)
Euclid Crane & Hoist, Euclid, O.
Northern Engineering Works, Detroit, Mich.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Sprague Electric Co., New York City.
Whiting Fdy. Equipment Co., Harvey, Ill.
Yale & Towne Mfg. Co., New York.

HOISTS.

(Hand.)
Northern Engineering Works, Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.
Yale & Towne Mfg. Co., New York City.

HOISTS.

(Pneumatic.)
Curtis & Co. Mfg. Co., St. Louis, Mo.
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Northern Engineering Works, Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.

HOISTS.

(Skip.)
Otis Elevator Co., New York City.

HOSE.

(Pneumatic.)
Cleveland Pneumatic Tool Co., Cleveland, O.

INDUSTRIAL RY. EQUIPMENT.

Atlas Car & Mfg. Co., Cleveland, O.
Johns-Manville, H. W., Co., New York, N. Y.
Northern Engineering Works, Detroit, Mich.

IRON ORE.

Rogers, Brown & Co., Cincinnati, O.

KAOLIN.

Paxson Co., J. W., Philadelphia, Pa.
Whitehead Bros. Co.,
Providence, New York, Buffalo.

LADLES.

Calumet Engineering Works, Harvey, Ill.
Northern Engineering Works, Detroit, Mich.
Paxson Co., J. W., Philadelphia, Pa.
Stevens, Frederic B., Detroit, Mich.
Whiting Fdy. Equipment Co., Harvey, Ill.
Wonham, Sanger & Bates, New York City.

LADLE DRYERS.

Pangborn Company, Thomas W., New York.

LADLE HEATERS.

Monarch Engrg. & Mfg. Co., Baltimore, Md.
Pangborn Company, Thomas W., New York.
Rockwell Furnace Co., New York.

LAMPS.

(Arc.)
Adams-Bagnall Electric Co., Cleveland, O.

LEAD.

Federal Fdy. Supply Co., Cleveland, O.
Stevens, Frederick B., Detroit, Mich. (Ceylon.)

LEAD.

(Black.)
Federal Fdy. Supply Co., Cleveland, O.
Paxson Co., J. W., Philadelphia, Pa.

MACHINERY.

(Wood Working.)
Baldwin, Tuthill & Bolton, Grand Rapids, Mich.
Crescent Machine Co., Leetonia, O.

MATCH-PLATES.

Goodale Co., Kalamazoo, Mich.

MECHANICAL DRAFT APPARATUS.

American Blower Co., Detroit, Mich.
Sirocco Engineering Co., Detroit, Mich.
Sturtevant, B. F., Co., Tyde Park, Mass.

METALS.

Birkenstein & Sons, S., Chicago, Ill.
Damascus Bronze Co., Pittsburg, Pa.

METALLURGISTS.

Gulick-Henderson & Co., Pittsburg, Pa.
Stoughton Engineering Co., New York City.

MODELS.

(Made to Order.)
Freeman Pattern Works, Toledo, O.

MOLD DRYERS.

Hauck Mfg. Co., Brooklyn, N. Y.
Monarch Engrg. & Mfg. Co., Baltimore, Md.
Pangborn Company, Thomas W., New York.

MOLDING MACHINES.

Adams Co., Dubuque, Iowa.
Arcade Mfg. Co., Freeport, Ill.
Ardelt & Sons, Eberswalde, Germany.
Berkshire Mfg. Co., Cleveland, O.
Buch's Sons, Elizabethtown, Pa.
Combined Foundry Supply Co., Buffalo, N. Y.
Demmler & Bros., Wm., Kewanee, Ill.
Herman Pneumatic Mach. Co., Zelienople, Pa.
Killing Molding Machine Co., Davenport, Ia.
Lawlor Improved Jarring Molding Machine Co., J. J., Pittsburg, Pa.
Linn Mfg. Co., Springfield, O.
Mumford Molding Machine Co., New York City.
Osborn Mfg. Co., Cleveland, O.
Paxson, J. W., Co., Philadelphia, Pa.
Pridmore Co., Edward A., Chicago, Ill.
Pridmore, Henry E., Chicago, Ill.
Smith, J. D., Fdy. Supply Co., Cleveland, O.
Tabor Mfg. Co., Philadelphia, Pa.
Turner Machine Co., Philadelphia, Pa.

MOTORS.

(Electric.)
Levett Mfg. Co., Matawan, N. J.

OIL.

(Burnease.)
New Era Lustre Co., New Haven, Conn.

PACKING.

(Rubber Sheet.)
Smooth-On Mfg. Co., Jersey City.

PARTING.

Curtius, Thos. M., New York City.

PARTING COMPOUNDS.

Federal Fdry. Supply Co., Cleveland, O.
McCormick, J. S., Co., Pittsburg, Pa.
Obermayer, S., Co., Cincinnati, O.
Paxson, J. W., Co., Philadelphia, Pa.
Whitehead Bros. Co.,
Providence, New York, Buffalo.

PATTERN LETTERS.

Cleveland Fillet Co., The, Cleveland, O.
Obermayer, S., Co., Cincinnati, O.
Paxson, J. W., Co., Philadelphia, Pa.
Shanafelt Mfg. Co., Canton, O.

PATTERN LUMBER.

Thompson, Lewis, & Co., Philadelphia, Pa.

PATTERNS.

(Metal and Wood.)
Allison & Lewis Pattern Works, Dayton, O.
Freeman Pattern Works, Toledo, O.
Herman Pneumatic Mach. Co., Zelienople, Pa.

PATTERN SHOP EQUIPMENT.

Standard Pattern Works Co., Cleveland, O.

PHOSPHORIZERS.

Dixon Crucible Co., Jos., Jersey City.
McCullough-Dalzell Crucible Co., Pittsburg, Pa.

Let the Opposition Lie as it likes.

Everybody knows that the **International Harvester Co.**, is one of the greatest, if not the very greatest, manufacturing concerns in the land after the U. S. Steel.

They equipped their **Plano Plant** with the Ridgway Steam Hydraulic.

They equipped their **Auburn Plant** with the Ridgway Steam Hydraulic.

They equipped their **Akron Plant** with the Ridgway Steam Hydraulic.

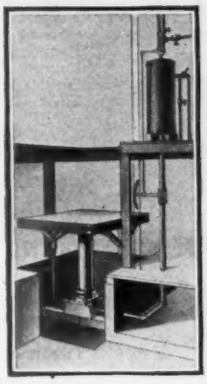
And now Mr. Foundryman, listen:

The International Harvester Co. at Milwaukee, are building one of the biggest foundries now going up in the United States and are

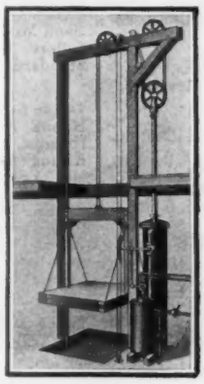
EQUIPPING IT THROUGHOUT WITH
RIDGWAY STEAM HYDRAULIC ELEVATORS

and if you are real wide awake you too will

HOOK 'ER TO THE BILER



Direct Acting



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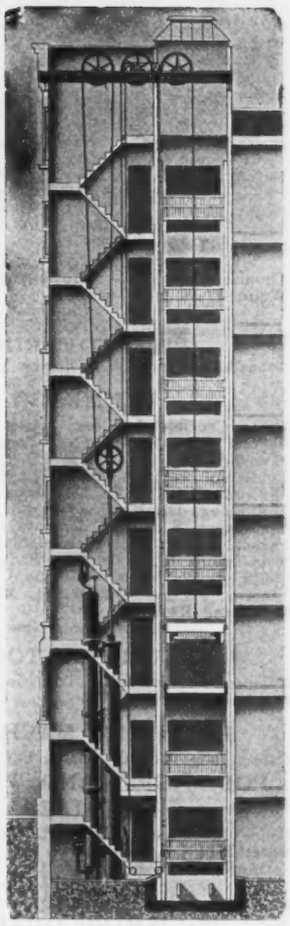

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